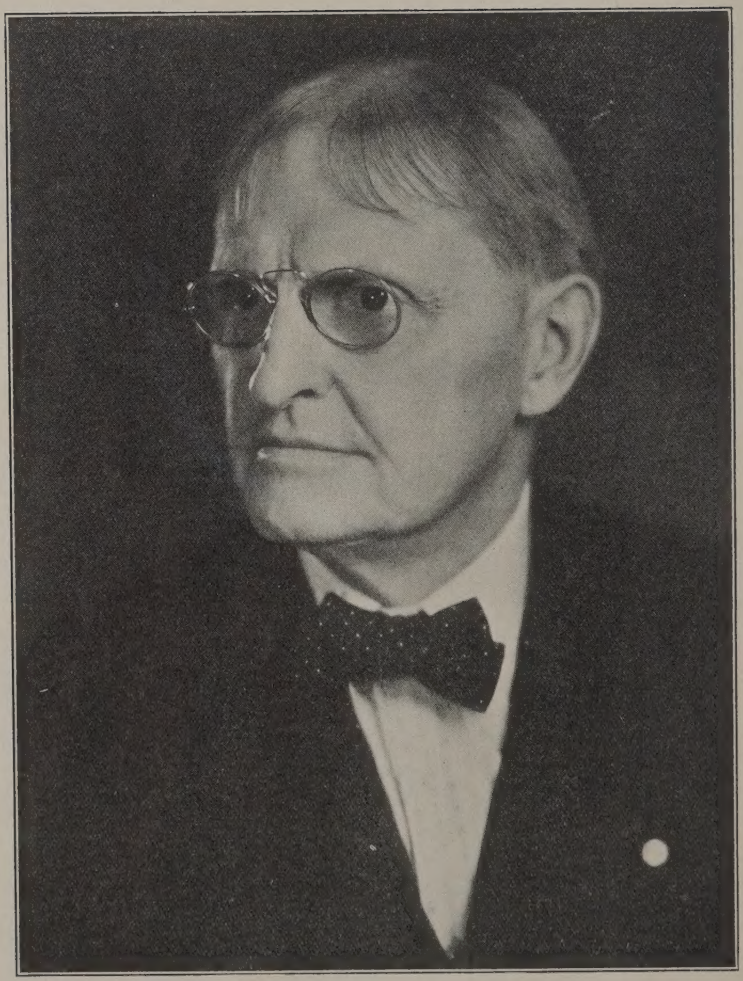

Professor Henry Baldwin Ward

The Journal of Parasitology

Volume XIX DECEMBER, 1932 Number 2

PROFESSOR HENRY BALDWIN WARD AND THE JOURNAL OF PARASITOLOGY[1]

W. W. Cort

The gift by Professor Henry B. Ward of the Journal of Parasitology to the American Society of Parasitologists and the beginning of its publication as the official organ of this society is an event of importance to all American parasitologists. It seems appropriate, therefore, at this time to consider the history of this journal for the period of almost two decades during which Dr. Ward has been its manager and editor. In the future when Dr. Ward's contribution to his chosen field as a teacher, an investigator, an administrator, and an editor can be more truly appraised the results of his years of work in developing the Journal of Parasitology will undoubtedly be considered among his most notable achievements.

The first number of the Journal of Parasitology appeared in September, 1914. It took courage, optimism and confidence in the future to launch an American journal of parasitology at that time. The active research workers in the field were very few. Dr. Ward's own laboratory was practically the only center in the United States where special facilities were available for the training of men for careers in parasitology. In fact there was little evidence of recognition of this subject as a separate field. The only society in parasitology was the Helminthological Society of Washington, a strong but purely local organization. A few scattered zoologists were engaged in teaching and research in parasitology in universities and colleges, a few zoologists and fewer veterinarians were working on the broad subject of veterinary parasitology and studies on human phases of the subject were chiefly concerned with programs for the control of hookworm disease and malaria. It looked doubtful if there would be either sufficient contributors or subscribers for a journal of this type.

Discussion of the possibility of starting in the United States a journal devoted to the field of parasitology began as early as 1911. Dr. C.

[1] I wish to express my thanks to Dr. Ward for placing at my disposal information in regard to the early days of the Journal and for the tabulation of helpful information.

W. Stiles and the late Dr. Brayton H. Ransom were chiefly instrumental in advising Dr. Ward to take the responsibility of its publication. The original plan was to publish the first number in January, 1914, but delays in correspondence and in procuring the necessary financial backing postponed the start until September of that year. The first circulars announcing the new journal were sent out in January, 1914. Valuable advice and assistance were given by Dr. George H. Simmons, then secretary of the American Medical Association and the editor of its journal. The early correspondence shows that it was Dr. Simmons who really decided on the name for the new journal. Some workers in the field felt that this journal should have been called the American Journal of Parasitology to avoid confusion with the British journal, Parasitology. As a matter of fact there is no evidence that any confusion of the slightest significance has ever arisen. It seems possible on the other hand that if the journal had been designated the American Journal of Parasitology there would have been more difficulty in obtaining the support from outside the United States that was so vitally important. In fact from the very first the Journal of Parasitology has been international in its material, in its point of view and in its support. At one time in the early years the number of subscribers from foreign countries was greater than from the United States.

At the start small subsidies were obtained from the universities represented on the Editorial Board. Support has also been received from time to time from certain laboratories as payments for special illustration or for longer articles. Some further incidental support has also been obtained from individuals who wish to remain anonymous. Without this extra support the Journal of Parasitology could not have been started and maintained in the early years of its existence.

In the correspondence before the issuance of the first number much hearty approval and many promises of support came from other countries. A list of foreign collaborators was decided upon and published in the second number (December, 1914). This list contained many of the most distinguished names in the field representing almost every country where important work was being carried on. These original collaborators have been constant supporters of the Journal. The fact that the Journal started just at the outbreak of the World War brought into the situation a number of factors that were not at all foreseen. In spite of the interest of these collaborators as shown by correspondence, by the contribution of papers and by aid in gaining foreign subscribers, it became necessary to remove their names from the inside of the cover page. In fact as soon as the list of foreign collaborators was printed letters were received by the Editor questioning the advisability of including certain names on the list. Arguments that science is above the

limitations of national boundaries were to no avail, and the communications increased in number and violence of opinion until it seemed wise to eliminate the whole list. This was done without explanation or comment in the March number of 1917.

The subscription price of the Journal of Parasitology was at first two dollars a year. The war brought about increased costs of printing, engraving, and labor which made it necessary to increase this price with volume seven to three dollars. As can be seen from the records this was done with little or no loss of subscribers since the subscription list of volume seven was 378 and that for volume eight was 408. An examination of the records of subscribers for the Journal shows a steady increase. From 195 for volume one the number increased until by volume eight there were over 400. After this naturally the proportional increase was a little slower. A peak of almost 600 was reached for volume sixteen, which level was just about maintained through volumes seventeen and eighteen. That this failure to increase in the last three volumes was due primarily to the depression is shown by the large number of old subscribers dropping out.

An analysis of the material published in the Journal of Parasitology gives a number of points of interest (Table 1). This table shows what a very large proportion of the pages were always given over to the publication of research articles. It also shows the growth in size and gives a graphic picture of the extent to which the journal was able to cooperate with the Helminthological Society of Washington and with the American Society of Parasitologists. That the Journal of Parasitology with its financial limitations was not in any way able to take care of the rapidly increasing volume of material available for publication in the field of parasitology is shown by the large numbers of monographs and papers published during this period in the Illinois Biological Monographs, the American Journal of Hygiene, the Transactions of the American Microscopical Society, in various governmental publications and in the veterinary, medical and zoological journals of this country.

From the first the Journal of Parasitology reflected the diversity of the field which it covers. While the subject of helminthology is best represented important articles on both protozoology and medical entomology are found in every volume. While the Journal has of course reflected the dominance of systematic and morphological work in the field of parasitology in the United States which has lasted up until the last six or eight years, it is not without significance that the first article in volume one was an experimental study and that a considerable proportion of the articles in the first volume were devoted to human parasitology. It can be correctly stated that the Journal has never represented the work of any group to the exclusion of others. In fact it has

TABLE I.—*An analysis of the material published in the Journal of Parasitology from 1914–1932. The figures denote numbers of pages*

	Volume																		Totals
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI	XVII	XVIII	
Announcements	4																		4
Articles	186	185	175	170	191	194	171	171	213	200	172	181	253	220	244	218	199	262	3,605
Helminthological Society of Washington	10	9				4	23	5	26	10	46	15	8	26	27	12	14	22	257
American Society of Parasitologists											4	20	20	17	17	14	15	24	131
Book Reviews and Notes	7	10	7	6	5	6	10	10	9	10	10	8	7	17	10	14	10	10	166
Indices	2	4	4	4	4	4	4	4	4	4	4	4	4	4	4	6	4	6	74
Total Text Pages	209	208	186	180	200	208	208	190	252	224	236	228	292	284	302	264	242	324	4,237
Pages of advertisements	17	22	21	21	22	17	20	26	28	28	28	28	30	28	22	20	20	34	432
Number of advertisements	22	27	25	25	26	22	28	38	43	44	44	44	44	39	31	25	24	40	591
Number of articles	27	29	22	28	27	32	28	26	28	26	22	31	31	30	31	34	30	38	520
Number of plates	9	12	13	12	20	15	14	29	24	23	33	26	16	15	23	16	21	27	348
Number of text figures	45	16	24	18	24	18	53	11	14	11	25	9	12	15	20	18	13	27	373
Number of tables	5	6	10	12	22	30	4	7	17	8	9	4	47	48	20	18	21	32	320

been able to publish from the very first all papers that were of sufficient merit to pass the scrutiny of its Editorial Board. When in any discussion the question of inadequate representation of any phase of parasitology has arisen, Dr. Ward has always answered that he would welcome especially papers in that field. If the Journal of Parasitology has failed to completely reflect in its pages the remarkable shift toward the experimental side that has come in the last few years in American parasitology, it has been because certain groups of workers had other methods of publication more easily available and because the size limitations of the Journal prevented the acceptance of longer papers. The readiness with which Dr. Ward accepted the papers of young workers has been a source of encouragement to many young men struggling to do research, and has stimulated many a man to continue his work. On the whole the Journal of Parasitology has been a reflection of the research activities of American parasitologists and as far as the material was available to it has given a place to every phase of the subject.

Something needs to be said of the Editorial Board. Of the eleven names that appeared on the cover of the first number of volume one, seven are still found on that of the June, 1932 number. Two of the most active of the original Editorial Board are no longer alive, Brayton H. Ransom and Allen J. Smith. Both of these men contributed largely in the early years of the Journal. In fact Dr. Ransom was one of the original group who planned the Journal and until his death was always an active worker on its Editorial Board. The fifteen men who have served with Dr. Ward during part or all of the eighteen years that he edited the Journal represent all phases of parasitology and are among the American leaders in this field. It is of interest that the new Editorial Committee and Editorial Board of the Journal of Parasitology in its present status as the official organ of the American Society of Parasitologists includes seven of this group.

The establishment of the American Society of Parasitologists in 1925 was a natural outcome of the remarkable development of the field of parasitology in the United States, a development in which the Journal of Parasitology had an important part. Dr. Ward was the first president of this society and served for four years on its Council. It was natural, therefore, that from the very first the Journal and the Society should be in the closest cooperation. The announcement of the organization of the Society was first published in the March number, 1925, of the Journal, and beginning with the next volume the programs of the annual meetings, which included abstracts of the papers presented, have been published each year. Later the policy was adopted of publishing the address of the retiring president and important symposium papers. This and other forms of cooperation led to the pro-

posal for a permanent relationship and the Council of the American Society of Parasitologists appointed on December 17, 1927, a committee to consider the possibility of making the Journal of Parasitology the official organ of the Society. A circularization of the Society in this same year showed 83 per cent of the 281 members voting in favor of the union. At this time Dr. Ward made the statement that he planned to give the Journal to the Society as soon as he became convinced that its strength was sufficient to guarantee the future of the Journal. With the growth of the membership of the Society to almost 550 it seemed that this time had been reached and at the meeting held December 28, 1931, at New Orleans, the Council appointed a new committee which was instructed to take all possible steps to obtain an official journal. This committee was able to arrange all the details necessary for taking over the Journal and Dr. Ward's promised gift to the Society became an accomplished fact. The formal announcement of the transfer was, therefore, made in the September number, the first published under Society auspices.

It is interesting to contrast the conditions under which the American Society of Parasitologists undertakes the publication of an official journal with those that confronted Dr. Ward and his Editorial Board eighteen years earlier. Interest in parasitology during this period in the United States has increased by leaps and bounds. There are now more than a dozen universities where advanced degrees can be obtained in this subject. Courses are being given in most of our larger universities and many colleges and the emphasis on parasitology in schools of veterinary medicine, medical schools and schools of public health has greatly increased. The increased numbers interested in parasitology is shown by the rise in membership in the American Society of Parasitologists to well over 500. Perhaps most striking has been the increase in research workers and the great increase in the volume of the work being published. Some of this increase has been due to the development of programs for the control of human parasites and some is accounted for by the expansion of governmental and state agencies for the study and control of the parasites of domesticated animals. The greatest increase, however, has come by the development of centers in a number of universities where groups are working in the field and graduate students are being trained. In universities and colleges in every section of the country are to be found research workers trained in parasitology each developing the subject to the best of his ability. The published work in parasitology in the United States last year was enough to fill half a dozen journals the size of the Journal of Parasitology. Certainly the present situation seems most favorable for the further development of a journal devoted to this field.

The Journal of Parasitology under the editorship of Dr. Ward has had an important part in this remarkable development. It has been during this period the only journal devoted exclusively to this subject in the Western Hemisphere and has constantly encouraged the younger men by publishing their articles. The fostering of the Journal has been only a part of Dr. Ward's contribution to the development of his chosen subject. Men trained in his laboratory are widely scattered all over the United States and are building up new centers of teaching and research. Already their students are finding a place among the younger workers and the time is not far distant when the students of Ward's students' students will begin to enter the field. And so Dr. Ward can continue his part in the journal which he founded and to which he devoted so much of his effort, by the work of his students and their students as editors and contributors. The effect of his personal efforts in behalf of the Journal of Parasitology will long be felt and it is particularly fitting that the statement " Founded by Henry Baldwin Ward " should be permanently placed on its cover.

OBSERVATIONS ON THE BEHAVIOUR OF THE SARCOPHAGID FLY, *WOHLFAHRTIA VIGIL* (Walk.)

NORMA FORD

University of Toronto

INTRODUCTION

For two months during the summer of 1931 observations were made on the behaviour of the sarcophagid fly, *Wohlfahrtia vigil,* the larvae of which cause cutaneous myiasis in infants and young mammals. Walker (1920, 1922) was the first to publish accounts of this disease in America and recently (1931) he has given a resumé of some eight cases in man which had been brought to his attention. Johannsen (1926) recorded the occurrence of *W. vigil* in young rabbits and Kingscote (1931) in a fox puppy.

The larvae of the fly are found in abscess-like lesions, the small opening of which is filled by the posterior extremities of the maggots, thus giving the appearance of pus. (The eruption is suggestive of impetigo.) The affected infants are usually in a pitiable condition which was described to the writer in the following words by Dr. N. McKinnon: "An infant, two weeks old, had about 40 lesions scattered over the body, arms and face, especially the eyelids. For approximately 24 hours it had been extremely irritable, crying and refusing its feedings. It had a slight fever, was dehydrated and looked sick (pitiable in appearance). The irritability, crying and refusal of food, with consequent dehydration and sickly appearance may have been due entirely to the irritation and inflammation in the skin and subcutaneous tissue. It is possible, however, that the larvae, alive or dead, or products of the larvae (secretions or excretions) were toxic for the infant and that the symptoms observed were due, in part, to absorption of such toxic material. The rapid recovery of the infant, as is usual after removal of the larvae, tends to support the former view."

On June 15, 1931, a case of cutaneous myiasis was reported from the Sick Children's Hospital in Toronto. The infant, four months old, had lesions on the left shoulder, upper part of the chest and neck, and the navel. About eight or ten larvae were removed, five of these from one lesion, in which the opening was unusually large, being approximately one-sixth of an inch in diameter. Only four of the larvae were uninjured and three of these were reared on liver by Dr. Walker. They pupated successfully, two males and a female emerging on July 3rd and 5th.

Working with these flies interesting and unexpected observations were made. Being flesh-flies one would expect that they would have

been much attracted to meat either fresh or stale, but this was not the case. The flies were indifferent to the meat offered them, although the room would soon be swarming with other flesh-flies and greenbottles if the window were left open. *Wohlfahrtia vigil* fed almost continually on sugar and even at the time of larviposition showed only a secondary interest in the meat. This has an important bearing on the problem of how larviposition normally takes place. Patton and Evans (1929) assumed, because Walker (1920) had reared the larvae on meat, that "these breeding experiments clearly point to the fact that *W. vigil* is a semi-specific myiasis-producing fly normally breeding in decaying animal matter." They also suggested that "it is possible that this fly is attracted to infants by the smell of dirty napkins, etc." We have found, however, the attraction to be quite a different thing from this, and of such a nature that it need no longer be considered a disgrace or a sign of uncleanliness for a child to become infected with the larvae of *W. vigil*. One might cite a case in Toronto to illustrate the popular bias in which the parents of a child felt they had a definite grievance against a hospital, because they considered that through gross neglect their baby had become parasitized; they were finally convinced that the infection had occurred in their own garden and while the infant had every care.

LONGEVITY

The flies on emergence were transferred to a fairly large cage (approx. 3 x 2 x 2 feet) and here the female lived to the old age of 53 days, depositing larvae at two different periods. The males, which are much shorter-lived, survive from only 10 to 17 days. In the female the first signs of old age were not evident until about 28 days when the tip of one wing broke, and not until the 43rd day were both wings broken.

FEEDING HABITS

One of the chief points of interest was the feeding habits of the fly. As mentioned above, it had been expected that *Wohlfahrtia vigil* would be attracted to meat, fresh or decomposing, yet strangely enough the flies showed no interest in meat. Throughout the experiment liver was kept in the cage, in the three stages, fresh, stale and badly decomposed, but the flies paid no attention to it (except on a rare occasion when an individual was seen sipping the fluid which had gathered). On the other hand the flies would feed all day on sugar. They had a curious habit of feeding from only one lump and quarreling over it, although there were three or four lumps in the cage: the one becoming badly discoloured, while the others were left spotless.

During one part of the experiment the menu offered to the flies consisted of sugar, water, cream, liver, slices of apple, and flowers of the

golden-rod. Sugar and water were the main items of their diet, although the male fly was observed to feed frequently on the nectar of the flowers, thrusting his proboscis roughly and clumsily among the flower-heads. If roused at night by a light the flies would go directly to eat sugar. With feeding habits such as these, it was most interesting to discover the behaviour of the flies during larviposition.

LARVIPOSITION

Three days after emergence the female mated and five days later we commenced a series of experiments in which either a guinea-pig or a rabbit was placed in the cage for periods of a half hour, an hour, or two hours at a time.

On the first day the fly paid no attention to the animal (a guinea-pig). Then a half-grown rabbit was shaved over its back and placed in the cage. The fly, however, showed no interest in the fine thin skin of the rabbit nor in the broken areas on the skin, although we had expected that *Wohlfahrtia vigil* like other myiasis-producing flies, would be attracted to sores or abrasions.

On the following afternoon while the rabbit was dozing the fly crawled up its paw and under its chin. The rabbit started nervously and shook the fly off. The next day the fly showed an increased interest in the host animal, and repeatedly approached it, always in front, walking over its feet until shaken off, or crawling among its whiskers. The flies are very sluggish, and whenever the rabbit was lumbering about the cage they were in constant danger of injury or death.

From now on it seemed definitely the head and face that attracted the fly. The insect would walk all around the rabbit, then commence crawling up over the feet, or else alight on the face or head. Indeed the eye seemed to be the point of attraction, and the fly would strike at that organ repeatedly. The smooth skin of the shaved back was quite disregarded.

On the eighth day after mating, the fly persistently lit on the rabbit's head or approached the face by way of the front paws. The rabbit, although dozing a good deal, always roused when the fly approached.

Finally on the afternoon of this day, when a guinea-pig was put in the cage, *W. vigil* immediately lit on the head close to the eye, and poured out a stream of white larvae on the brown fur of the animal. The stream resolved itself into actively moving maggots which in a few seconds had disappeared among the long hairs. The animal began to scratching vigorously at its head, so that seven larvae were scratched off. Of these, three were preserved in alcohol, four placed on liver.

Later the female was held on my hand for a quarter of an hour but she made no further attempt to larviposit. A rabbit was put in the cage with no result.

On the day following larviposition the fly had no interest in the animals, and from now on it was usual for the rabbit or guinea-pig to rest quietly at one end of the cage, the fly at the other, or else for the fly to eat sugar.

From these observations it would seem that in a furred animal the eye is the point of attraction; due either to the moist secretions or the brightness of the organ. It is also significant that in the cases with infants recorded in Ontario the larvae have entered the skin most commonly on the neck, chest, shoulders, arms, cheeks, and eyelids. It is probable that *W. vigil* strikes on the cheek of the child and that from there the larvae migrate to places of concealment in the folds of the body and then burrow into the skin. In tropical diseases of man dipterous larvae are also frequently associated with the eye.

Eight days after larviposition the fly was taken to Algonquin Park (150 miles north of Toronto) and for two weeks guinea-pigs, rabbits and sterile liver were shipped up regularly from the Connaught Laboratories, University of Toronto. Occasionally the fly appeared interested in an animal but no additional larvae were deposited.

On August 7th observations were again being made in Toronto and two days later a male of the second generation emerged (the only one of the four larvae which transformed at this time). The female by now was appearing old and somewhat inactive. Attempts to crawl up the glass were futile, only short flights were taken, and she rested much of the time on the floor of the cage. If both flies were placed in 2 oz. bottles the male at once flew out of his bottle but the female was so feeble that her attempts to climb up the sides ended only in falling on her back. However, they mated when the male was seven days old and the female forty-one days old. Although insects possess no ductless glands, there would appear to be evidence here of internal secretions, for at forty-five days the old fly seemed to rejuvenate and was observed walking up the glass again and wrestling with the male.

On the forty-sixth day the female's interest in the host animal revived and she stood watching the guinea-pig and stamping her front feet. The following day she was running about over the liver and after the guinea-pig was put in the cage she kept close to the animal for two hours. During this time she rested on the floor of the cage directly under the guinea-pig's chin, or stood on her hind legs, reaching up towards the animal's mouth; attempted to crawl up the side of the cheek, where the long hairs offered a poor foot-hold to the aged fly; tried to crawl up the whiskers or at other times went under the body of

the guinea-pig; and once or twice crawled up over the hip. Three times in succession the fly crawled straight for the eye, but each time the guinea-pig shook it off violently.

For two days this interest continued. The fly would stand "pawing the air," trying to reach high above to the guinea-pig's mouth, and giving little jumps into the air. However it seemed hopeless for her to get a foot-hold and on the third day after her interest had been awakened in the animal (when forty-nine days old) larvae were deposited on the liver. The piece of liver chosen was three days old, dried on top, but moist close to the glass. Six larvae were found all working their way under the liver, close to the glass.

Persistently, but hopelessly, the fly attempted to crawl up the animals whenever they were placed in the cage. The following day seven larvae were found in another dish of liver. Then all interest ceased in animals or liver.

With the larvae of this second brood, I tried to parasitize myself, placing a larva on the skin of my under arm. The larva at once tried to burrow, holding on by its anterior segments, rasping with its jaws, and throwing the posterior part of the body high in the air at each scrape. After five minutes my skin was only slightly roughened. Apparently adult skin is much too resistant.

On the other hand when a larva was placed on a dead mouse (recently born) it crawled actively over the body, disregarding open wounded tissue, and took up its position underneath, where in about ten minutes it had worked its way under the skin.

Of the several larvae which successfully pupated, only two additional flies transformed. These, a male and a female, emerged not until six months later, and, although they belonged to different generations, they came out within a few days of each other. Unfortunately we overlooked the male which therefore starved. The female lived about a month.

The diet of liver was probably unsuitable for the larvae and this may account for the high mortality. We plan in future experiments to feed the larvae on subcutaneous tissue and hope thereby to carry them from generation to generation.

NOTES ON SPECIAL BEHAVIOUR

After watching the four adults of *Wohlfahrtia* fairly constantly for more than a month it became evident that individuals are quite distinct in disposition and behaviour. To begin with the males and females are very different, then again the males differ among themselves. The males are much more active and given to playing. Early in the experiment the two males of the first generation would wrestle

and play like puppies. Later the male of the second generation continually teased his old mother, approaching her face to face, slapping and pulling at her wings. Sometimes he would take up a position about two inches to one side of her, then with a jump land in front, and again with a jump to the other side of her. Now he would pull at her wings or they would sit facing each other, slapping and teasing, or chasing each other in short flights.

The larger male was a "dog in the manger" with regard to the sugar. If the female came to feed he deliberately pushed her off the lump and, although she struck back, she was forced to keep to the side, while he sat on top. Five weeks later when the female was 39 days old, it was she who sat atop the lump of sugar and drove off her son, the young male of the second generation (four days old), although three days later the tables were turned and the female was again being driven away.

One of the most interesting observations was concerned with the female recognizing and defending her own property, namely the lump of sugar, when the guinea-pig began to nibble it. The fly showed her excitement by stamping her front legs, alighting beside the animal and walking underneath it, or flying in circles about the guinea-pig's head and generally annoying it until it left the food.

ACKNOWLEDGEMENTS

I wish to thank Dr. E. M. Walker for placing the specimens of *Wohlfahrtia* at my disposal and for his valuable assistance and advice; also to thank Dr. N. McKinnon for his many helpful suggestions and kind co-operation in supplying us with necessary materials from the Connaught Laboratories.

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PRENATAL INFECTION WITH THE DOG HOOKWORM, *ANCYLOSTOMA CANINUM**

A. O. Foster

In the course of investigations on hookworm infection in dogs, it has been possible during the last seventeen months to study the conditions of infestation in four litters of puppies born in the laboratory to mothers of known infection history. Two of the mothers were repeatedly infected both before and during pregnancy, one was given a single infection thirty-eight days before birth of the puppies, and the fourth mother was infected before pregnancy only. The last two cases have been regarded as control litters. It is believed that these observations indicate that prenatal infection is probably the usual thing when a dog is infected with filariform hookworm larvae during late pregnancy. The experiments also throw some light on the question of immunity to hookworms and on that of larval migration after oral infection.

The finding of prenatal infection was entirely accidental. The effort was being made to determine whether puppies born to mothers which were highly resistant to hookworms, as a result of long repeated infection, would carry over any of this resistance either congenitally or as a result of nursing from resistant mothers. To this end, two bitches which had been repeatedly infected with *A. caninum* and showed a marked resistance, were bred and the infections continued periodically throughout pregnancy.

In the first case the total exposure of the mother was 5,494 larvae given *per os* over a period of 195 days. Of this number, 2,500 larvae were administered during pregnancy, 500 being given every two weeks beginning on the day of impregnation and ending one week before the birth of five puppies. The daily egg production of this dog's infestation originally rose to a peak of about 1,100,000 eggs per day and had fallen to a level of about 100,000 when the puppies were born, indicating the development of considerable resistance. All five puppies showed hookworm ova in the stools when examined individually by the Lane Method on the eleventh day. The fecal specimens for examination were obtained with a rectal syringe. All of the puppies of this litter died when from twelve to eighteen days old, and harbored about equal hookworm burdens, the least being 45 and the most 71. The

* From the department of Helminthology of the Johns Hopkins University School of Hygiene and Public Health. This work was made possible by the aid of the International Health Division of the Rockefeller Foundation.

The writer wishes to acknowledge the aid and criticism of Dr. W. W. Cort.

fact that the puppies appeared to be growing rapidly and enjoying the best of health during the first week, and then suddenly became progressively anemic and emaciated until death resulted in all cases, together with the observation of the intestine at autopsy, presented a typical picture of acute fatal hookworm disease. Table 1 gives the age at death and the number of worms recovered from the puppies of this first litter.

TABLE 1.—*Data on first litter, born May 24, 1932*

Pup No.	Age at death in days	Adult hookworms recovered	Immature ascarids
1	12	61	1
2	15	45	3
3	16	63	1
4	17	57	0
5	18	71	2
Total		297	7

In the second case, the total exposure of the mother was 13,480 larvae given *per os* over a period of 230 days. Of this number, 3,000 were given during pregnancy, three doses of 500 larvae each being given at intervals of two weeks beginning the day after impregnation, and a fourth dose of 1,500 larvae being given fifteen days before the birth of eight puppies. The egg production of the mother's infestation at first rose to a peak of about 1,000,000 eggs per day and had fallen to a level of about 200,000 when the puppies were born, indicating the development of a reasonably pronounced resistance to infection. In this case the puppies were born prematurely by about five days (58 days gestation), and one was dead. Autopsy of the still-born puppy revealed no mature worms, but upon direct examination of the organs after maceration, one partially developed larva was obtained. Later, five larvae apparently in the filariform stage were recovered by isolation of these organs in the Baermann apparatus. A second puppy died the following day and no worms were found upon direct examination of the organs, but six active larvae were obtained by Baermann isolation. On the night of the third day, puppy number 3 was eaten by the mother, leaving only the tail and one leg. On the eleventh day individual fecal examinations were made on the remaining five puppies, four of which were positive for hookworm ova at this time. The puppy which was not positive by this examination was autopsied the following day (12 days old) and 82 mature hookworms were recovered. The remaining four puppies showed consistently heavy hookworm infestations when examined again by the Lane Method on the thirteenth, fifteenth, and

seventeenth days after birth, until finally all eight puppies had succumbed to the infestations by the twenty-fifth day. Table 2 gives the age at death and the number of worms recovered from the puppies of this second litter.

TABLE 2.—*Data on second litter, born June 29, 1932*

Pup No.	Age at death in days	Hookworms recovered	Ascarids recovered
1	0	1 partially developed larva found upon direct examination of tissues. 5 larvae obtained by isolation of organs in Baermann apparatus.	1 immature ascaris in tissues
2	1	No worms found upon direct examination. 6 larvae recovered in Baermann apparatus.	None
3	3	Eaten by mother—no record.	
4	12	82 mature hookworms	22 immature ascaris
5	22	114 " "	16 " "
6	24	179 " "	21 " "
7	25	145 " "	20 " "
8	25	115 " "	6 " "
Total (5 pups)		635 hookworms	85 ascaris

A third case of almost equal importance is one in which the mother was repeatedly and heavily infected before impregnation, and harbored a heavy worm burden throughout the periods of pregnancy and nursing, and in which none of five puppies harbored hookworms. Two of these puppies, however, died during the first week which was attributed to the fact that this mother was retained on a deficient diet until one week before the puppies were born. No hookworms were found in these puppies at autopsy and the three remaining ones were raised and remained negative to Lane examinations until they were infected for experiments at a much later date.

In the fourth case, the mother was given a single infection of 2,000 larvae 38 days before the birth of six puppies. These puppies were given individual fecal examinations on the eleventh, fifteenth, and eighteenth days and all were consistently negative. Further examinations revealed one positive on the twenty-first day, three on the twenty-second day, five on the twenty-fifth day, and all positive on the twenty-eighth day. That these findings which were so different from anything hitherto encountered should come at a time when the animals were not receiving their usual care, suggested immediately the possibility of contamination within the cage as the source of infection. The cleanings from the cage on the twenty-second day were isolated in a Baermann apparatus and twenty-six infective larvae were recovered. This demonstrated at least the probability of infection from contamination, a fact

which was already indicated by the unique nature of the infections. As indicated above, circumstances made it easy to account for the presence of larval hookworms in the cage at this time. When the puppies were only a week old, our animal man was forced to stay at home two weeks because of illness. During this interval the animals were cared for by individuals of less experience with that phase of the work. For these two weeks the mother was locked in the cage with the puppies and a bedding was prepared for the puppies by placing a box of wood shavings in the cage. These shavings were not changed oftener than every two or three days, and the box was never washed with hot water. It was clear at once that under these conditions, the mother, who harbored an infestation, was forced to defecate within the cage, and environmental conditions were such as to permit a rapid maturation of larvae within the wood shavings. In all other cases, our regular routine of animal care, which has been described in earlier publications from this department, has been followed. Briefly reviewed, this routine involves washing all animal cages twice daily with hot water and steam. The puppies are born and raised in the regular dog cages. The additional care given to puppies consists in providing a clean burlap bag for bedding every morning. While the cage is being washed, the puppies are placed in a clean pail or bucket. Meanwhile, a dog who is nursing puppies is allowed to run at liberty within the animal room, with the consequent result that she does not soil the cage in which the puppies are raised. The circumstances involved in the infection of these puppies have been outlined in some detail because this case constitutes the only instance of hookworm infection from cage contamination occurring in this laboratory over the period of several years during which the present methods of animal care have been used. The infestations in these puppies differed from those in the prenatally infected puppies in so many particulars that it is felt that this otherwise unfortunate circumstance has in reality contributed to the evidence for prenatal infection, as described for the first two litters. The worms in these puppies matured at various times when the puppies were from 21 to 28 days old, the infestations were light, and all of the puppies remained in good health. In contrast to this, the puppies of the first two litters harbored about equal worm burdens, the worms matured uniformly when the puppies were 11 days old, and all of the puppies succumbed to the effects of the worms.

It is believed that our observations are further controlled by the fact that during this same period, three other litters of four, six, and eight puppies respectively were raised from mothers freed of their worms, all members of these litters remaining free from hookworm infestation until used experimentally.

DISCUSSION

That the puppies of the first two litters discussed above were infected prenatally is reasonably clear on the basis of the findings outlined above. Of the seven litters under observation, the puppies of only two showed prepatent periods of eleven days, were uniformly heavily infected, and succumbed to the injuries of the worms. The mothers of these two litters were the only two which were repeatedly infected throughout pregnancy. In addition, the finding of larvae in the tissues of the still-born puppy of the second litter is evidence in itself of a prenatally acquired infestation.

It is possible also that the ascaris infestations were prenatal as the findings fit in well with the earlier observations on prenatal infestation with the same form (Augustine, 1927). Furthermore the chance of exposure of the mother to ascaris infection was much greater than that of the puppies since the mothers were allowed to exercise at liberty in the animal rooms.

So far as the writer is informed, this is the first experimental demonstration of the occurrence of prenatal infection in the case of any of the hookworms. Adler and Clark (1922) examined thirteen young dogs from two to fifteen days old, representing eight different litters, and found larval or adult forms of *Ancylostoma caninum* in six. It is interesting to note that two of these positives were five-day-old puppies which harbored only larval forms, while the other four positives were puppies from thirteen to fifteen days old and harbored mature worms. As the nature of these infections parallels the results in the present study, it is believed that Adler and Clark were correct in interpreting their findings as indicative of intrauterine infection. Prenatal infestation has also been shown to occur with *Schistosoma japonicum* (Narabayashi, 1914), and *Belascaris marginata* (Fulleborn, 1921; Shillinger and Cram, 1923; Augustine, 1927), and has been suspected for the human hookworm (Howard, 1917; DeLangen, 1923).

Some interesting features suggested by the present studies are:

I. The development of the larvae was not initiated until birth of the puppies. The significance of this is not known, although Augustine has shown that it is true of Belascaris also. Narabayashi, however, reported finding schistosome eggs in the feces of new-born infants.

II. The larvae administered *per os* in these cases must have migrated in great numbers since, in Case I more than ten per cent, and in Case II more than twenty per cent, of the total larvae given the mothers throughout pregnancy were recovered from the intestines of the puppies in the form of mature worms. This fact is interesting because of its bearing upon the problem of migration after oral infection. It is

possible also that the larvae migrate in greater numbers in resistant hosts.

III. The puppies of these two litters born to resistant mothers showed a marked susceptibility to infection. In his study of prenatal infestation of Belascaris, Augustine stated that of two bitches infected with embryonated ova during pregnancy, one showed no worms at all at autopsy and the other only a few worms. The puppies born to these bitches, however, harbored heavy infestations of Belascaris. He explained this as indicative of an age-immunity in the bitch against this parasite, the larvae showing a decided preference for foetal tissues. It is significant that both in the present study and in Augustine's study there was a condition of lack of resistance, even prenatally, in puppies born to very resistant mothers. Such findings apparently do not fit in well with a serological explanation of this type of resistance, an explanation which has been offered by Graham, Ackert, and Jones (1932) for the resistance of the chicken to the nematode *Ascaridia lineata*.

IV. The fact that both litters of puppies were killed by hookworm disease, prenatally acquired, within twenty-five days after birth suggests a possible relationship between exposure to infection with the human hookworm during pregnancy and infant mortality.

ABSTRACT SUMMARY

All the puppies of two litters born to mothers infected with hookworm larvae during pregnancy acquired prenatal infestations of the dog hookworm, *Ancylostoma caninum*. Development of the larvae in the prenatally infected puppies did not take place until after birth. The fact that approximately ten and twenty per cent of the larvae given the mothers during gestation were recovered from the puppies as mature worms, was taken as indicating a wide-spread migration of hookworm larvae after oral infection, a phenomenon which it is suggested may be associated with the resistance of the host. The marked susceptibility of the puppies born to very resistant mothers was pointed out to be difficult to reconcile with a serological explanation of this type of resistance. Since all of the prenatally infected puppies died within twenty-five days, the suggestion is made that there may be a relation between human hookworm infection during pregnancy and infant mortality.

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THE INGESTION OF THE LARVAE OF *TENEBRIO MOLITOR* L. (MEAL WORM) BY MAN

E. Harold Hinman and Ernest Carroll Faust*

Among the numerous arthropods which may serve as intermediate hosts of the rat tapeworm, *Hymenolepis diminuta,* grain infesting insects are probably the most important. Of these *Tenebro molitor,* the meal worm, is believed by Joyeux (1920) and others to be one of the commonest hosts of the cysticercoid. This cestode occurs frequently among rats, mice, other murine species and is an occasional human parasite (Faust 1929). Keller (1931) calls attention to over a hundred cases of human infestation by this species. Human parasitization probably results from the accidental ingestion of infected insects living in cereals, such as flour and meal. Of the human cases, Chandler (1930) reports 23 from approximately 10,000 fecal examinations in India, Keller found 8 cases in Tennessee from 31,000 examinations and Sellers had 13 cases from Georgia in 11 years. In over 8,000 examinations during the past 4 years not a single case has been discovered in this laboratory in spite of the abundance of the tapeworm among experimental rats.

Very few records of human ingestion of meal worms exist in the literature. Hope (1840) tabulated 9 cases of *Tenebrio molitor* parasitizing man. Forestus (1619) first recorded this insect from the stomach of a young girl. Tulpius (1652) had two cases, one from the bladder and another from the nose of female patients. Acrel (1799) found 50 *Tenebrio molitor* in the stomach of a female. Bateman (1811) had three cases, one occurring in the abdomen and navel, another from the nose and one from the intestines. Pickells (1824) reported 50 larvae and 7 adult insects being discharged from the stomach of a young woman. Hope reported one case of these insects from the stomach of a female patient. In a case reported by Riley and Howard (1889) two larvae of *Tenebrio molitor* had been vomitted by a female patient. The authors suggest that they had been ingested in corn-meal mush, a food which does not need chewing. Brumpt (1921) reported the evacuation, *per anum,* of the larva of this species.

The writers wish to present a record of two cases of ingestion of larvae of *Tenebrio molitor,* by man. In the first, a case of Dr. W. R. Hand of Philadelphia, Miss., a man vomited the mature beetle larva during the summer of 1929. In the second, an immature larva was recovered in a tonsil at tonsilectomy, Oct. 1930, and sent in by Dr. S. J.

*From the Parasitology Laboratory, Department of Tropical Medicine, Tulane Medical School, New Orleans, Louisiana.

Lewis of Beaumont, Texas, for identification. This latter record is very unique and probably represents the first instance of insect parasitism of the human tonsil.

During the past year a number of experimental dogs in our laboratory passed in their feces both larvae and adults of *Tenebrio molitor* and *Tribolium ferrugineum* Fabricius[1] in considerable numbers. Many of these specimens were evacuated in an excellent state of preservation. The infestation was found to have occurred through the feeding of calf meal to the dogs.

While there are at least two dozen arthropods (Oldham, 1931) which may harbor cysticercoids of *H. diminuta*, yet the majority of these seldom come into direct contact with man, in such a manner as to be ingested by him. This is especially true of Myriapods, cockroaches, earwigs, most of the Lepidopteran hosts, and dermestids. Of the list of intermediate hosts cited by Oldham it would seem that meal worms and fleas are the insects most apt to be swallowed by man and there is little chance of rodent fleas being ingested except by a child. The fact that meal worms occur so frequently in human foods, that rats and mice are commonly associated with cereals, and that meal worms are at least occasionally ingested by man, certainly suggests their responsibility for human infestation by *H. diminuta*.

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[1] The writers desire to acknowledge their indebtedness to Dr. A. G. Boving of the U. S. National Museum for his kind identification of the beetle larvae.

DOES YEAST AFFECT THE GROWTH AND INFECTIVITY OF THE NEMATODE, *ASCARIDIA LINEATA* (SCHNEIDER), in CHICKENS[1, 2]

T. D. Beach and J. E. Ackert

Yeast is recognized as being one of the main sources of the vitamin B complex. That the food accessory now known as the vitamin B complex is required for normal growth in chickens was shown by Eikjman in 1890 according to Sherman and Smith (1931). Eikjman experimentally produced symptoms in fowls similar to those of beri beri by feeding them polished rice. He was able to prevent these symptoms or cure the disease by feeding the fowls extract of the polishings.

That certain vitamins are essential for the maintenance of normal resistance of chickens to an intestinal parasite has been demonstrated by Ackert and his associates (1927). In 1931, Ackert, McIlvaine and Crawford found more and larger *Ascaridia lineata* in chickens maintained on rations deficient in vitamin A than in the controls similarly parasitized and supplied with this vitamin. Ackert and Spindler (1929) found that while the lack of vitamin D did not appear to lower the resistance of the chickens to the growth and development of *A. lineata,* the supply of this vitamin minimized the effects of the parasites on the chickens.

Ackert and Nolf (1931) in studying the effects of rations deficient in the vitamin B complex, found a larger number of *A. lineata* in the chickens whose diets lacked this vitamin. This suggested a lowered resistance of the hosts to the parasite. Longer worms, however, were found in the groups of fowls receiving the vitamin B in the form of yeast. This result which suggested the possibility of the growth factor in yeast having a stimulative effect upon the growth of the *A. lineata* led to the execution of experiments which form the basis of this paper.

MATERIALS AND METHODS

The chickens used in these experiments were obtained as day old, pure bred, white leghorn chicks from accredited hatcheries. They were raised in confinement under conditions which were adequate for normal growth (Herrick, Ackert and Danheim, 1923), the ration having been as follows: yellow cornmeal, 45 gm.; cracked wheat, 15 gm.; oatona (steel cut oats), 17 gm.; alfalfa leaf meal, 4 gm.; meat meal,

[1] Contribution No. 143 from the Department of Zoology, Agricultural Experiment Station, Kansas State College of Agriculture and Applied Science, Manhattan.

[2] Acknowledgment is made to Mr. G. L. Graham for his suggestions and aid in the execution of the experiments.

10.5 gm.; powdered skim milk, 6.5 gm.; and cod-liver oil, 2 gm. At the beginning of each experiment the chicks were weighed, banded and separated into groups of equal size and weight. Exceptionally heavy and light birds were not included in any of the experimental groups. Weights were recorded each week for each chicken and the average gain calculated. The results obtained thereby were used in the construction of growth charts and in biometric treatment. From these data it was possible also to study the effects of parasitism.

The worm egg cultures used for parasitizing were made as follows: gravid females of *A. lineata* from recently drawn chicken intestines were placed in a clean petri dish. The anterior ends were cut and the internal organs pressed out through the cut end. The uteri were separated and the proximal ends containing the highest percentage of fertilized eggs macerated in another clean petri dish. For culturing a 0.001 per cent solution of formaldehyde was used. The cultures were then placed in an electric incubator kept at a temperature of 30° C. and the eggs allowed to develop to the infective stage. To parasitize each chicken, 50 embryonated eggs (Ackert, Graham, Nolf and Porter, 1931) were counted out on a slide under the low power of the compound microscope. They were then washed onto a filter paper with distilled water and a pinch of cornmeal added. In parasitizing, the filter paper containing the parasite eggs and the cornmeal was rolled into a pellet and forced down the oesophagus and into the crop of the chicken. In Experiment I the birds were parasitized at the age of six weeks and in Experiment II at the age of nine weeks.

At the end of three weeks of parasitism the chickens were killed, the small intestine removed, and the contents flushed into a flask by means of warm water under pressure (Ackert and Nolf, 1929). The *A. lineata* were then preserved in 10 per cent formalin and later isolated and counted.

In measuring, the nematodes were placed a few at a time in a petri dish which rested on a glass plate. Under the plate a strong light was used to cast a shadow of the worms vertically through a lens which increased it six diameters on the ground glass of a photographic bellows. This enlarged shadow was traced on onion skin paper. The lengths were then taken by running a calibrated tracing wheel over the tracings which reduced their size six diameters. The use of this method of measuring insured accurate results as the tracing wheel could be made to follow any twist or turn that the worm might have assumed as a result of killing and preserving. Comparisons were made by using as criteria the number of worms per group which supplied the data for the degree of infestation and the length of worms per group which furnished the data for the rate of growth of the worms.

EXPERIMENTAL DATA

Experiment 1. One hundred white leghorn chicks of the same hatch reared on an adequate diet for five weeks were weighed, banded and segregated into three groups of thirty each, the total weights of which were the same. The remaining ten were discarded due to their excessive or deficient weights. On the following day one group was put on a ration consisting of the regular diet containing an adequate amount of vitamin B complex plus 6 per cent by weight of Brewer's yeast (Brewer's group). Another group was put on a ration consisting of the regular diet containing an adequate amount of vitamin B complex plus 20 per cent by weight of Baker's yeast which due to the moisture content was equivalent to 6 per cent of dry yeast (Baker's group). The third group was kept on the regular diet containing an adequate

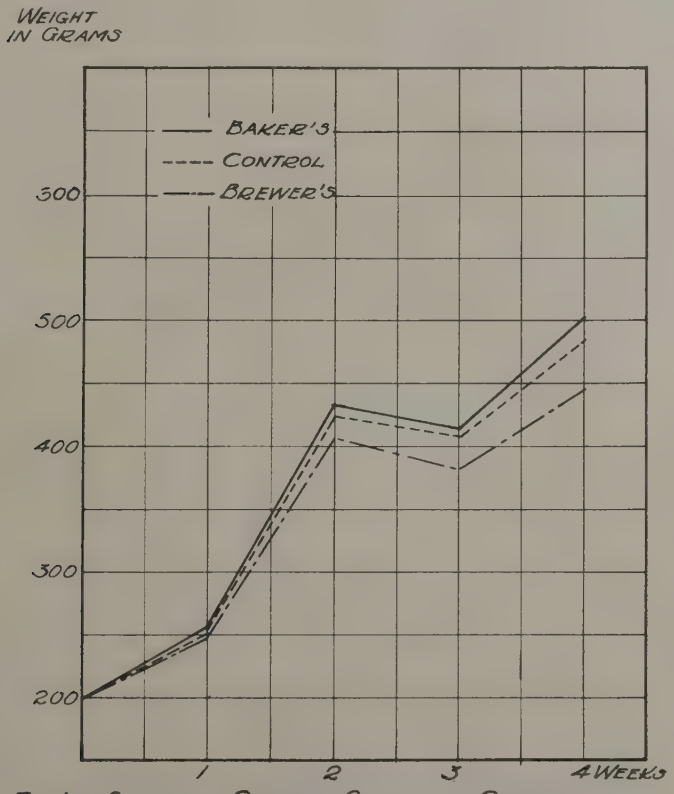

FIG 1. SHOWING GROWTH CURVES OF GROUPS OF CHICKENS ON BAKER'S YEAST, BREWER'S YEAST AND CONTROL DIETS.

amount of vitamin B complex as controls (control group). One week after the groups were put on their respective diets each chicken was parasitized with 50 embryonated eggs of *A. lineata.* The chickens were six weeks of age at that time. Three weeks later they were killed and the worms removed. Not one chicken was lost during the experiment.

After being placed on the rations the birds grew rapidly until the second week of parasitism when all three groups not only failed to gain but lost weight (fig. 1). These results are in accord with those of Ackert and Herrick (1928) who tested effects of these nematodes on chickens throughout various periods of parasitism and found the second week to be the most deleterious to the chicken. This is doubtless due to the young worms burrowing into the intestinal epithelium and destroying Lieberkühn's glands during this period (Ackert, 1923). During the third week of parasitism the worms withdraw into the lumen of the intestine and the greatest severity of the parasitism begins to pass. That this condition probably occurred in this experiment is indicated by figure 1 which shows that all three groups of chickens gained in weight during the third week of parasitism. From a study of these gains it was found that the average gain of the Baker's group was 87.6 gm. and of the Brewer's 64.6 gm., or a difference of 23 gm. which was significant (6.11 times its probable error). While the reasons for this difference have not been determined, it is thought that the somewhat sour taste of the Brewer's yeast may have resulted in a slightly smaller consumption of the ration by this group of chickens. No significant difference in gains occurred between either of these groups and the control group during this period.

TABLE 1.—*Showing numbers and lengths of Ascaridia lineata from chickens in Experiment 1.*

Group	Number of Hosts	Mean	Stand. Dev.	P. E. of Mean	Act. Diff. of Means	P. E. of Diff.	Ratio, $\frac{D}{E}$
			Numbers of Worms				
Baker's	30	4.44	3.16	0.39	2.46	0.88	2.79
Control	30	6.90	6.41	0.79			
Brewer's ...	30	9.06	7.54	0.92	2.16	1.21	1.79
Baker's	30	4.44	3.16	0.39	4.62	1.0	4.62
			Average lengths of worms (mm.)				
Baker's	30	19.41	10.89	0.63	0.42	0.71	0.59
Control	30	19.83	6.86	0.32			
Brewer's ...	30	20.92	7.48	0.3	1.09	0.44	2.46
Baker's	30	19.41	10.89	0.63	1.51	0.7	2.15

The biometrical treatment of the data on numbers of worms removed from each chicken showed that the Baker's group yielded an

average of 4.44 worms per chicken as compared with an average of 6.9 worms from the controls, or a difference of 2.46 worms. As this difference was only 2.79 times its probable error, it was not significant (Table 1). The Brewer's group had an average number of 9.06 worms per chicken as compared with the 6.9 from the controls, the difference being 2.16 worms which was also within the limits of experimental error. However, the difference between the average number from the Baker's group, 4.44 worms as compared with 9.06 worms from the Brewer's group was 4.62 worms. This is 4.62 times the probable error and may be considered significant.

The data obtained from measuring the worms showed that the average length of those from the Baker's group was 19.41 mm. as compared with 19.83 mm. from the controls. This difference of 0.42 mm. was not significant (Table 1). The worms from the Brewer's group had a mean length of 20.92 mm. as compared with 19.83 mm. for the controls. The difference of 1.09 mm. likewise was not significant. The average length of 19.41 mm. for the Baker's group as compared with 20.92 mm. for the Brewer's group showed a difference of 1.51 mm., which was 2.15 times its probable error and therefore not significant.

Concerning the results of this experiment, the fact that there were significantly more *A. lineata* in the chickens of the Brewer's group than in those of the Baker's group would seem to indicate that the ration containing Baker's yeast had increased the resistance of these chickens. However, since this difference was between two yeast groups and not between the controls and a yeast group, and since there were no significant differences in the rate of growth of worms between any two of these groups, the writers consider that palatable yeast in the presence of an adequate diet does not affect the growth and infectivity of *A. lineata* in chickens. It appeared that the presence of Baker's yeast in the ration increased the rate of growth of the chickens whereas is possible that this variation might have been due to differences in the palatability of these two rations.

Experiment 2. The second experiment followed closely the procedure of Experiment 1 except that the parasitizing was done four weeks after the chickens had been put on their respective diets. One hundred-fifty pure bred, white leghorn day old chicks of the same hatch were raised for five weeks in confinement on the same adequate diet as those in Experiment 1. At the end of that time they were banded, weighed and segregated into four groups of 43 each, the remainder being discarded due to their excessive or deficient weights. The groups of chickens were put on their respective diets, viz., a Baker's group receiving the regular diet containing an adequate amount of vitamin B in

addition to 20 per cent by weight of Baker's yeast, a Brewer's group receiving the regular diet containing an adequate amount of vitamin B plus 6 per cent of Brewer's yeast and an additional group receiving the regular diet containing an adequate amount of vitamin B complex plus 6 per cent by weight of dry Baker's yeast (dry Baker's group). Besides these groups, there was a control group receiving the regular ration containing an adequate amount of vitamin B complex.

After the chickens had been on their respective diets four weeks they were parasitized, each with 50 embryonated eggs of *A. lineata* from a culture which had been incubated three weeks. After three weeks of parasitism the chickens were killed, the intestines removed and the parasites isolated. During the experiment several of the birds died, eight of them being from the control group, two from the (moist) Baker's group, two from the Brewer's group, and none from the dry Baker's group. The fact that the greatest mortality occurred in the control group would seem to indicate that the yeast helped to keep the birds in a more healthy condition.

Upon examination of the growth curves (Fig. 2) it will be seen that those in the dry Baker's and the (moist) Baker's groups made better gains than those of the control group and the Brewer's groups, while the Brewer's group made less gain than the controls. However, there were no significant gains made by any one group over another.

Comparing the numbers of worms it was found that the Baker's group had an average of 3.24 worms per bird and the controls, 2.8 worms. The difference was 0.44 worm which is not significant. The Brewer's group had an average of 3.41 worms and the controls 2.8 worms, or a difference of 0.61 worm which likewise was not significant. The average of 2.28 worms of the dry Baker's group as compared with the 2.8 worms of the controls made a difference of 0.5 worm which was within the range of experimental error. The consideration of the differences between the groups in which yeast was used showed that the difference in the averages of the Baker's group and the Brewer's group was 0.17 worm which was not significant. Between the Baker's and dry Baker's groups the difference was only 0.96 worm and likewise not significant. The dry Baker's and the Brewer's difference amounted to 1.12 worms which was 1.82 times its probable error and therefore within the range of experimental error.

The average length of worms found in the Baker's group was 12.56 mm. as compared with 11.43 mm. in the controls. The difference was 1.12 mm. which was 2.39 times its probable error and not significant. The worms in the Brewer's group had an average length of 14.24 mm. and the controls 11.43 which made a difference of 2.8 mm. which was not significant. The 12.23 mm. average from the dry Baker's group as

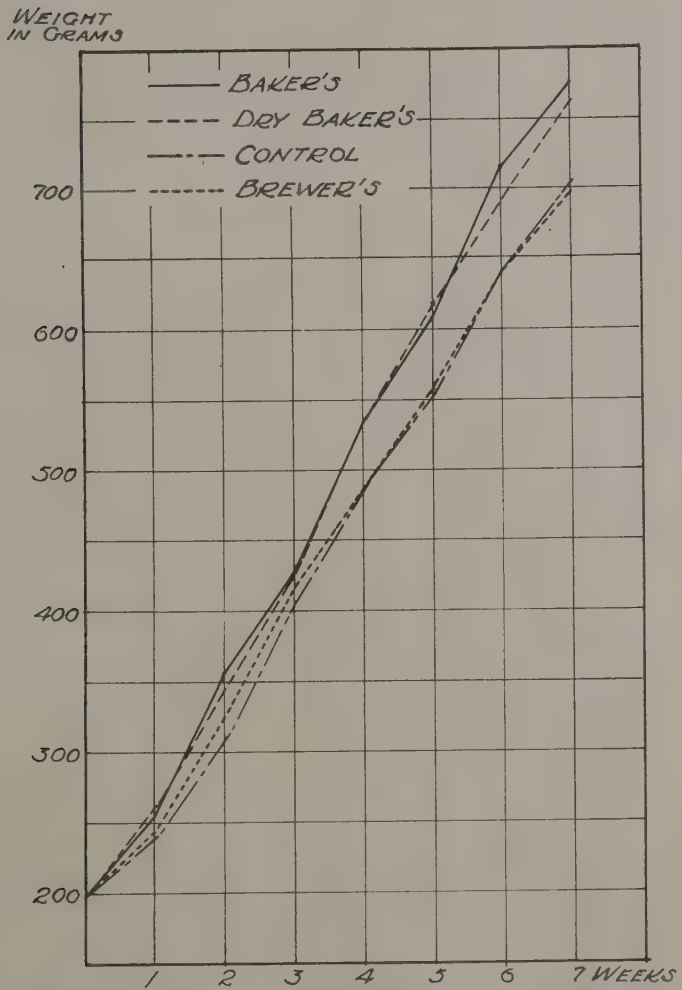

FIG. 2. SHOWING THE GROWTH CURVES OF CHICKENS ON (MOIST) BAKER'S, DRY BAKER'S YEAST, BREWER'S YEAST, AND CONTROL DIETS

compared with 11.43 for the controls made a difference of 0.8 mm. which was within the range of experimental error. The consideration of the groups in which yeast was used showed that the difference in the averages between the Baker's and Brewer's was 1.68 mm. which was not significant. Between the Baker's and the dry Baker's groups the

difference was 0.33 mm. which was not significant. The dry Baker's and Brewer's difference amounted to 2.01 mm. which likewise was not significant. The results of this experiment indicate that yeast (six per cent by weight), when fed in the presence of an adequate diet, does not alter the infectivity or affect the growth of *A. lineata* in chickens. However, the presence of Baker's yeast in the ration, whether dry or moist, seemed to increase the rate of growth of the chickens.

SUMMARY

1. Two controlled experiments involving 262 chickens were conducted to ascertain if yeast was a factor in the infectivity and growth of *Ascaridia lineata* when the host chickens were fed different forms of yeast in addition to an adequate diet.

2. After being on the regular ration for five weeks, the chickens were banded, weighed and segregated into groups of equal size and weight. The first group received, in addition, 20 per cent (by weight) of Baker's yeast; and the second group 6 per cent of Brewer's yeast. In Experiment 2, an additional group received 6 per cent (by weight) of dry Baker's yeast. A control group on the regular ration was maintained in each experiment.

3. Each chicken was parasitized with 50 embryonated eggs of *A. lineata* after being on the special rations (one week, Experiment 1; four weeks, Experiment 2). At the end of three weeks of parasitism the experiments were terminated and the worms isolated.

4. Throughout Experiment 1 all groups gained in weight except during the second week of parasitism when they not only failed to gain but lost weight. In the final week of the experiment, the Baker's group made a marked (significant) gain over that of the Brewer's group, but not over the gain of the control group. It is thought that the difference between the two yeast groups may have been due to decreased palatability of the Brewer's ration. Likewise in Experiment 2 the chickens receiving the Brewer's yeast made the poorest gains.

5. The criterion used for ascertaining the degree of infectivity was the number of worms removed at autopsy; that for judging the growth of worms was their length.

6. In Experiment I there were no significant differences between the control group and the experimental groups for numbers of worms. There was a significant difference in numbers of worms between the Baker's group and the Brewer's group. As this was a difference between two forms of yeast and not between the control and experimental groups, it was not considered as an index of altered infectivity, especially since the results of Experiment 2 showed no significant differ-

ences between any of the groups either in numbers of worms or in lengths of worms.

7. It has been concluded from these experiments that yeast does not contain a special growth factor for *Ascaridia lineata* when used in the presence of an adequate diet; nor does it, under the same conditions, constantly alter the infectivity (degree of infestation) of this nematode.

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ON THE IMMUNITY OF SNAILS INFESTED WITH THE SPOROCYSTS OF THE STRIGEID, *COTYLURUS FLABELLIFORMIS*, TO THE PENETRATION OF ITS CERCARIA*

GERALD F. WINFIELD

Among digenetic trematodes a few cases are known in which a single species of snail may serve both as first and second intermediate hosts. An example of this is found in the life cycle of the strigeid, *Cotylurus flabelliformis*. Certain observations and experiments made during the summer of 1931 at the University of Michigan Biological Station indicated that when an individual snail harbors the sporocyst stage of this species it is highly immune to the penetration of the cercaria.

The life history of *C. flabelliformis* has been worked out in its various stages by a group of workers (Faust, 1917; Cort, 1917; Cort and Brooks, 1928; Hughes, 1929, and Van Haitsma, 1931). It has been shown that the sporocysts develop in a period of about six weeks in several species of snails among which are *Lymnaea stagnalis appressa* Say and *Lymnaea stagnalis perampla* Walker. These two varieties serve also as second intermediate hosts, into which the cercariae of this species readily penetrate and develop. It then takes about six weeks for the metacercaria stage which is of the tetracotyle type, to complete its development in the snails. When these mature tetracotylids are eaten by ducks they develop within a week into adults which Van Haitsma (1931) described as *C. flabelliformis*. This American species and its life history is very similar to the common European form which has been known until recently under the name of *Strigea tarda*.

The snails on which the observations and experiments reported in this paper were made were all collected in a single day from a restricted area on the shore of Douglas Lake at the mouth of Bessie Creek. Of the 150 specimens of *Lymnaea stagnalis appressa* and *L. stagnalis perampla*, which were brought in, about 40 were selected out from which the cercariae of *C. flabelliformis* were found to be escaping. During the period in which they were under observation these infested snails were all kept in individual bottles containing 40 cc. of water while the rest of the lot were kept in a single aquarium.

Direct observations on the penetration were made by placing large numbers of actively swimming cercariae of *C. flabelliformis* in Syra-

* From the University of Michigan Biological Station and the Department of Helminthology, School of Hygiene and Public Health of the Johns Hopkins University.

cuse watch glasses with individual snails. When an uninfested snail was observed under these conditions with a dissecting binocular the cercariae were seen to penetrate in large numbers. They first attached themselves to the surface of the snail and after making a few measuring-worm like movements they began to bore with their anterior ends into the tissue. Almost as soon as the anterior tip had entered the snail the tails were cast off. By the simple procedure of counting the number of freed tails and comparing them with the number of detached bodies present in the dish, an idea of the number of cercariae that had succeeded in penetrating could be had. In one case in the course of some fifteen to twenty minutes during which the snail was under observation a large number of cercariae were seen to penetrate. A comparative count of free tails and bodies confirmed this observation. Four days later when the snail was autopsied 58 young metacercariae of *C. flabelliformis* were counted. This indicates that in the 15 to 20 minutes of exposure at least 58 cercariae succeeded in penetrating this snail.

On the other hand when an infested snail, that is one from which the cercariae of *C. flabelliformis* were escaping, was treated in a similar fashion even though hundreds of cercariae from another infested snail were confined in a very small quantity of water with it, it was possible to observe only one or two penetrating. For the most part the cercariae after moving along the surface of the snail for some little distance, swam away without attempting to penetrate and those that did attempt it seemed to have a great deal of difficulty in getting into the snail's tissue. After the snail had been exposed for three hours a count of about one fifth of the area of the watch glass was made and 33 bodies and 34 tails were found. This would seem to indicate that even after very much longer exposure than in the case of the uninfested snail only a very few if any cercariae had penetrated into this snail.

This resistance to penetration was even more strikingly shown by an experiment in which the number of developing metacercariae in a group of snails infested with the sporocysts of *C. flabelliformis* was compared with the number present in an uninfested group. The seven infested snails that were examined were taken at random from the group that had been isolated into separate bottles because cercariae of *C. flabelliformis* were found to be escaping from them. At autopsy all of the seven were found to harbor mature sporocysts of this species. For the 11 days that these seven infested snails had been in the laboratory before examination they had been isolated in separate bottles and had been exposed to from 450 to 2,000 new cercariae each 24 hours as was shown by the counts of the escaping cercariae. The six uninfested snails were taken at random from the aquarium in which had been

placed the group of snails from which cercariae of *C. flabelliformis* had not been found to be escaping at the time of the preliminary examination. The six snails at autopsy were all found to be negative for the sporocysts of *C. flabelliformis.* Their exposure to the cercariae of this species came about from the fact that several snails which were giving off cercariae of this species had been overlooked and had been left for the 11 days in the aquarium with the uninfested ones. While the exposure of these two groups was, therefore, not accurately checked it would appear that the uninfested group had had very much less exposure to cercariae than the infested one.

The examination for the developing metacercariae of *C. flabelliformis* was made by teasing apart very carefully the tissue of the snail in a Syracuse watch glass. Then this teased material was examined under a binocular microscope and the developing metacercariae stages counted. These stages can be easily distinguished from the bodies of cercariae on the one hand by their large size and the vacuolization of their tissues and from the mature tetracotylids which are fully developed and encysted. Fully developed tetracotylids of *C. flabelliformis* were present in varying numbers in both the infected and uninfested groups. They must have all been acquired before the snails had been brought into the laboratory since development to this stage is known to take about six weeks. It is probable that the mature tetracotylids in the infested snails had been acquired before the penetration of the miracidia from which the sporocysts and cercariae which they harbored had developed. Of course the accuracy of the counts is open to criticism since it is very difficult if not impossible to so finely divide the snail tissue as to expose every single developing metacercaria. However, the method of counting was exactly the same for both the infested and uninfested groups, and the examination and counting were done with as great accuracy as possible.

An examination of Table I shows that there were present at the time of autopsy a large number of developing metacercariae in the uninfested group while in those harboring the sporocysts and cercariae of *C. flabelliformis* the numbers were practically negligible. The very small numbers of these stages in the infested snails in spite of their very great exposure to the cercariae supports the direct observations made on the difficulty of the penetration of the cercariae into infested snails. The conclusion can, therefore, be drawn that when specimens of *L. stagnalis appressa* and *L. stagnalis perampla* are infested with the sporocysts of *C. flabelliformis* they become highly resistant to the penetration of the cercariae of this species, which normally penetrate into and develop in uninfested snails of these two varieties. Undoubtedly this immunity plays an important part in the survival of

TABLE 1.—*A comparison of the number of developing matacercariae of Cotylurus flabelliformis found in snails infested with the sporocysts of this species compared with those found in uninfested snails*

Infested snails		Uninfested snails	
Snail number	Number of developing metacercariae	Snail number	Number of developing metacercariae
1	none	1	2,275
2	3	2	1,123
3	2	3	2,900
4	none	4	2,525
5	29	5	950
6	none	6	1,700
7	none		
Average	4.8		1,912

snails harboring infestations of this trematode since it tends to prevent them from being attacked and overwhelmed by the great numbers of cercariae which escape.

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SOME CROSS TRANSMISSION EXPERIMENTS WITH GONGYLONEMA OF RUMINANT ORIGIN

By John T. Lucker

Zoological Division, Bureau of Animal Industry, U. S. Department of Agriculture, Washington, D. C.

INTRODUCTION

Until recently, the names *Gongylonema scutatum* and *Gongylonema pulchrum* have persisted in the literature of helminthology as designations for presumably distinct species of Gongylonema from ruminants and swine, respectively, despite the fact that certain helminthologists have called attention from time to time to their essential morphological similarity. As early as 1893, Railliet expressed the opinion that except for certain size differences, *G. pulchrum* Molin, 1857, appears to be identical with the form known to occur in various ruminants. It was not until 1925, however, that Baylis presented adequate comparative morphological data which warranted his conclusion that *G. scutatum, G. pulchrum* and *G. ransomi*—the latter species having been described from domestic swine in the United States by Chapin in 1922—are specifically identical. The specific differentiation had been based on differences in size, and especially on the length of the left spicule of the male, morphological characters shown by Baylis to be too variable in the above species of this genus to be considered as having specific value.

While Baylis' argument on the basis of morphology is entirely convincing, the question of host relationship adds a complicating factor to the problem of species specificity of zooparasites. It is possible for forms which occur in two different hosts to be morphologically indistinguishable, but host specific. So far as the ruminant Gongylonema is concerned, it had already been shown by Ransom and Hall (1915) and confirmed by Baylis, Sheather and Andrews (1926) that Gongylonema from cattle can be transmitted to sheep. However, negative results were secured by Ransom and Hall (1915) in an attempt to ascertain whether Gongylonema of bovine origin could be transmitted to swine. Baylis, Sheather and Andrews (1926), in an experiment involving two pigs, also failed to bring about this cross transmission, but a second attempt by these workers, reported later (1926), resulted in the infection of two pigs with Gongylonema of bovine origin. Though the pigs in question had been fed large numbers of cockroaches, *Blattella* sp., which had become infected with larvae as a result of previous ingestion of embryonated eggs of Gongylonema obtained from a calf, the resulting infection in the pigs was very light.

One pig yielded 9 and the other 14 worms, on post-mortem examination. The parasites were mature, but smaller than the usual size of the parent worms in their ruminant host. In view of these facts, Baylis, Sheather and Andrews concluded that Gongylonema is only an accidental parasite of swine.

In the United States Gongylonema is of fairly common occurrence in pigs, as is indicated by the fact that the meat inspection regulations of the United States Department of Agriculture provide for the examination of swine tongues for these threadworms. In order to account for the prevalence of Gongylonema in swine in the United States, it is necessary to assume either a ready cross transmissibility of these parasites from ruminants to swine, or to regard them as being specific to their respective host groups, though morphologically indistinguishable. The latter assumption is unavoidable if the evidence from the experiments referred to above must be accepted as final.

TRANSMISSION OF GONGYLONEMA FROM RUMINANTS TO SWINE

In view of the existing uncertainty with regard to the species of Gongylonema in question, it appeared desirable to secure further data on the problem of the cross transmissibility of Gongylonema from ruminants to swine and to determine whether young pigs might be more susceptible than older pigs to infection with Gongylonema from ruminants. It should be noted in passing, that in the data supplied by Ransom and Hall (1915) and by Baylis, Sheather and Andrews (1926), the ages of the pigs which were experimentally exposed to infection with Gongylonema of bovine origin are not given. Young pigs were used in the experiment described below, which was carried out by Schwartz and the writer and has already been reported briefly (1931).[1]

Eggs from gravid females of Gongylonema from sheep and cattle were fed to cockroaches, *Blatella germanica,* on July 25, 1930. On August 28, 1930, 34 days later, a cockroach was killed, and 60 encysted larvae isolated from it were administered by mouth to pig 1; on the same day pig 2 swallowed three infected cockroaches from the same lot, containing an undetermined number of larvae. The pigs were about two months old at the time of infection. On December 12, 1930, 106 days after experimental infection, the pigs were killed and examined post mortem for Gongylonema with the following results:

Pig 1. Worms were found at the base of the tongue near the epiglottis and along the sides of the tongue; only 3 worms were found in the wall of the esophagus. A total of 58 worms were recovered from this animal.

[1] The investigations reported in this paper were suggested to the writer by Benjamin Schwartz and were carried out under his direction.

Pig 2. 100 worms were removed from the wall of the esophagus and 107 worms were removed from the tongue. The distribution of the parasites in the tongue was similar to that noted in pig 1.

Three control pigs, litter mates of pigs 1 and 2, kept in an adjacent pen, were also killed on December 12 and examined for Gongylonema with negative results.

DISCUSSION OF RESULTS ON CROSS TRANSMISSION OF GONGYLONEMA FROM RUMINANTS TO SWINE

It is evident from these data, as well as from those supplied by Baylis, Sheather and Andrews, that pigs can become infected with Gongylonema of ruminant origin. Not only are these worms from ruminants capable of reaching fertile maturity in swine, but it is possible, as shown in the case of pig 1, for nearly all the infective larvae swallowed by a susceptible pig to develop in what Baylis, Sheather and Andrews were inclined to regard as an accidental host. While the number of infective larvae administered to pig 2 was undetermined, calculations based on the average number of larvae present in infected cockroaches of the lot involved in the experiment, warrant the belief that the majority of larvae administered to pig 2 developed in this animal. The resultant infection was thus not only relatively high but was also absolutely high, considering the probable number of larvae fed and the number of worms removed post mortem.

A morphological study of the worms obtained from pigs 1 and 2, involving a consideration of certain size relationships, has disposed conclusively of the status of *Gongylonema ransomi* described by Chapin from swine in the United States. Chapin separated *G. ransomi* from all other species of the genus Gongylonema, except *G. verrusosum*, by the length of the left spicule which, he states, is about 10.3 mm. long. The length of the left spicule of Gongylonema from domesticated sheep and cattle in the United States ranges from about 16 to 23 mm. It was, therefore, of considerable interest and importance to discover that the length of the left spicule in ten of the male specimens reared to fertile maturity in pigs 1 and 2 varied from 7 to 13 mm. These ten males varied in length from 15.0 to 25.3 mm. Ten male specimens, identified by Chapin as *G. ransomi* and deposited in the Helminthological Collection of the Bureau of Animal Industry were examined and the left spicules were found to range in length from 7.8 to 10.6 mm. Hence the experiment here recorded warrants the conclusion that the Gongylonema which have been described as *G. scutatum* and *G. ransomi* are the same species.

Baylis, Sheather and Andrews obtained 6 males from the pigs experimentally infected by them with Gongylonema of bovine origin. The specimens posesssed left spicules varying in length from 9 to 12

mm. These writers also considered that the experiment performed by them indicated the identity of *G. scutatum* and *G. ransomi*. They concluded that their experiment proved, in addition, the identity of *G. scutatum* and *G. pulchrum*, the latter being the name of the Gongylonema described from European swine. For this species, the range of size for the left spicule, as reported in the literature, is from 4.0 to 5.8 mm. The writer is unable to agree that the data supplied by Baylis, Sheather and Andrews, or those pertaining to experiment 1 reported in this paper, necessarily warrant any conclusion with reference to *G. pulchrum*. Specimens indistinguishable from this species have not been developed experimentally in pigs, either in the case reported by Baylis, Sheather and Andrews or in the experiment carried out by Schwartz and the writer.

TRANSMISSIBILITY OF GONGYLONEMA OF RUMINANT ORIGIN TO ANIMALS OTHER THAN SWINE

So far as can be determined from the literature, white rats are the only animals, other than swine, to which Gongylonema of ruminant origin have been transmitted. Baylis, Pan and Sambon (1925) fed two albino rats with the infective larvae of this parasite from cattle. The experimental host animals were killed 77 days after the last administration of larvae. A single immature female worm was found in one rat and a single male in a second rat. The left spicule of the male was 4.9 mm. long. Stiles and Baker (1927) secured infections in two out of eight rats to which they administered the infective larvae of Gongylonema obtained from cattle. One rat contained a female worm and the other contained a male worm.

Gongylonema larvae of unknown host origin occurring naturally in the beetles *Phanaeus vindex* and *Copris minutus* were fed experimentally to two domestic animals, a chicken and a rabbit by Cram (1931). The female Gongylonema which was subsequently recovered from the rabbit, and the male specimen recovered from the chicken, were tentatively identified by Cram as *G. ingluvicola*.

In order to secure additional data on the transmissibility of Gongylonema of ruminant origin to various animals other than swine, the experiments summarized in table 1 were carried out with the results indicated.

DISCUSSION OF EXPERIMENTS SUMMARIZED IN TABLE 1

It is evident from the data presented in table 1 that Gongylonema of ruminant origin is transmissible to rats, guinea-pigs, and rabbits; this parasite was not transmitted to a white mouse, two dogs and two chickens. It is interesting to note in this connection that carnivores are not known to harbor Gongylonema. Chickens are known to be hosts

TABLE I.—*Summarizing data relating to the transmissibility of Gonglonema of ruminant origin to various experimental animals*

Host Animal	Dates of Infections	Number of Larvae Fed	Date of Post-mortem Examination	Duration of Infection (Days)	Post-mortem Findings (Intact worms and location)	Remarks
Rat 1	Sept. 22, 1930	Undetermined	Jan. 7, 1931	107	Esophagus: 3 non-gravid females, 1 male	The left spicule of the male measured 3.79 mm. in length
Rat 2	Aug. 18, 1930	" (1)	Jan. 13, 1931	148	Esophagus: 9 females, 6 males; tongue: 2 females. (6 of the 11 females were gravid; 5 non-gravid)	Left spicules of males 5, 6, 5.4, 5.38, 4.53 and 5.03 mm. long, respectively
Rat 3	Oct. 9, 1930	"	Mar. 27, 1931	169	2 gravid females, 1 male. Location not noted.	Eggs obtained from female worms developed in cockroaches; left male spicule 6.3 mm. long.
Rat 4	Oct. 9, 1930	"	Mar. 30, 1930	172	Tongue: 2 worms; esophagus: 3 worms. (4 non-gravid females, 1 male)	Females contained eggs apparently infertile; the spicule of male 5.92 mm. long
Rat 5	Oct. 9, 1930	"	Mar. 30, 1930	172	Palate: 1 worm; esophagus: 2 worms. (2 gravid females, 1 male)	Eggs obtained from female worms developed in cockroaches; left spicule of male 5.84 mm. long
Rat 6	May 14, 1931	35 (2)	Oct. 28, 1931	167	Epiglottis: 1 male	The left spicule of this male measured 6.6 mm. in length
Guinea-Pig 1	Mar. 18 and 20, 1931	144	Apr. 8, 1931	21	Esophagus: 35 worms: palate: 1 worm; tongue: 5 worms. (All agamic)	37 larvae were fed on Mar. 18 and 107 more were given Mar. 20
Guinea-Pig 2	Apr. 1, 1931	Undetermined	Apr. 27, 1931	26	Esophagus: 25 worms; palate: 6 worms; tongue: 9 worms; lower jaw: 1 worm; cheeks: 7 worms. (All agamic)	

TABLE I.—(*Continued*)

Host Animal	Dates of Infections	Number of Larvae Fed	Date of Post-mortem Examination	Duration of Infection (Days)	Post-mortem Findings (Intact worms and location)	Remarks
Guinea-Pig 3	Apr. 18, 1931	130	June 4, 1931	47	Palate: 8 worms; upper gums: 8 worms; tongue: 4 worms; lower jaw: 6 worms; esophagus: 25 worms. (All agamic or exhibiting only incipient sex characters)	
Rabbit 1	Mar. 12, 1931	115	July 17, 1931	127	Esophagus: 59 worms; tongue: 30 worms; palate and jaws: 14 worms. (59 gravid females, 44 males)	Maximum length of worms (female) about 7 cm; left spicules of two males 14.3 and 12.3 mm. long, respectively
Rabbit 2	Apr. 1, 1931	Undetermined	Aug. 11, 1931	132	Esophagus: 8 gravid females, 7 males; tongue: 3 gravid females; palate: 4 gravid females, 3 males	
Dog 1	Apr. 10, 1931	73	June 16, 1931	67	No worms were found on macroscopic examination. The esophagus was examined microscopically also.	
Dog 2	Apr. 10, 1931	50	June 9, 1931	60	No worms were found No worms were found on macroscopic examination	
Mouse 1	Apr. 17, 1931	78	Aug. 17, 1931	122	No worms were found on macroscopic examination. The esophagus was also microscopically examined. No worms were found	
Chicken 1	Apr. 3, 1931	62	July 23, 1931	111	No worms found	
Chicken 2	Apr. 3, 1931	82	July 29, 1931	117	No worms found	

(1) The larvae were obtained from a cockroach which had ingested ova only 25 days previously.
(2) The larvae were obtained from females which had resulted from transmissions of Gongylonema of ruminant origin to white rats.

for *Gongylonema ingluvicola* Ransom, 1904, and for the more recently proposed species *G. crami* Smit, 1927. So far as can be judged from the above experiment, chickens are refractory to Gongylonema from ruminants. While the mouse used in the above experiment escaped infection, the problem of the insusceptibility of mice to Gongylonema from ruminants is by no means settled. Additional feeding experiments with mice are indicated, especially in view of the fact that the other rodent species tested by the writer became infected with the ruminant Gongylonema.

Ransom and Hall (1915) report that larvae of the ruminant *Gongylonema* did not develop in a white mouse. In view of the susceptibility of rodents to infection with Gongylonema of ruminant origin it is interesting to recall the experimental transmission of the rat form, *Gongylonema neoplasticum,* to a ruminant host, *Ovis aries,* reported by Leiper (1926).

The male specimen of Gongylonema which developed in the white rat fed infective larvae of bovine origin by Baylis, Pan and Sambon (1925) was probably immature, since so far as can be judged by the writer's experiments a period of time considerably in excess of 77 days is required by the ruminant Gongylonema for the attainment of sexual maturity in rats. Baylis, Pan and Sambon expressed no opinion on the question of the maturity of this specimen. The eight male specimens which were reared to maturity in white rats by the writer, maturity being judged by the coincidental finding of males with sexually mature females in the same host animal, possessed left spicules which varied in length from 4.53 to 6.3 mm. The variation in the length of the specimens was from 10.0 to 16.9 mm. These findings constitute the first experimental proof of the derivation from the ruminant Gongylonema of mature male specimens which are indistinguishable from *G. pulchrum,* so far as concerns the size of the left spicule.

SUMMARY

Gongylonema of ruminant origin has been transmitted to two pigs. A large proportion of the larvae fed developed to maturity in pigs.

The Gongylonema removed from the experimental pigs was morphologically indistinguishable from *Gongylonema ransomi,* and the experiment is regarded as affording more conclusive proof than has heretofore been offered that this species is identical with *G. scutatum.*

Administration of infective larvae of Gongylonema of ruminant origin to two dogs, two chickens and a white mouse did not produce infestations with Gongylonema in these animals.

The ruminant Gongylonema has been transmitted to white rats, guinea pigs and rabbits.

Eight mature male specimens which devolped in white rats as a result of the administration of infective larvae of Gongylonema of ruminant origin, possessed left spicules varying in length from 4.53 to 6.3 mm. Some of the specimens were indistinguishable from *G. pulchrum* for which species left spicules ranging in size from 4.0 to 5.8 mm. have been reported. Mature specimens indistinguishable from *G. pulchrum* have not previously been derived experimentally from the ruminant form.

On the basis of the data presented in this paper, *G. scutatum* and *G. ransomi* are to be regarded as synonyms of *G. pulchrum*. It is true that male specimens with the same spicule lengths as those reported for *G. pulchrum* have not as yet been developed experimentally in pigs by the transmission of the ruminant Gongylonema to these animals. However, the evidence presented in this paper shows that male specimens identical with those of *G. pulchrum*, so far as spicule sizes are concerned, have been derived from "*G. scutatum*" experimentally transmitted to white rats. This evidence is interpreted by the writer as affording an adequate reason for concluding, in agreement with the view of Baylis, that *G. scutatum, G. ransomi,* and *G. pulchrum* are specifically identical.

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VARIATIONS IN HOOKWORM DISEASE*

W. W. Cort

Over a period of several years a considerable amount of information has accumulated on the host-parasite relations of the dog and cat to their common hookworm parasite, *Ancylostoma caninum*. Observations have been made on various types of infestations with this parasite, both those naturally acquired and those produced experimentally. The types of infestation and the different kinds of effects produced have been considered in relation to the action of the parasite on the host and the reactions of the host against the parasite. Certain points of view have developed which it seems worth while to discuss in relation to this parasite in particular, to the interaction of host and their helminth parasites in general, and especially in regard to the light they may possibly shed on the variations in human hookworm disease.

Recent investigations clearly indicate that in the reaction of the host to the presence of hookworms and other nematode parasites there is something in addition to the attempt to compensate for the blood losses and other injuries produced by the worms. McCoy (1931) showed that when puppies were given repeated doses of hookworm larvae over a considerable period of time their infestations gradually accumulated until a severe anemia was produced. In a few cases the animals succumbed to the effect of the worms and died. In most of the cases, however, what appeared to be a crisis occurred. This was initiated in the majority of the cases by a sharp rise in the hemoglobin which was followed by a rapid expulsion of worms and the reduction of the infestation to a very low level followed by a gradual rise of the hemoglobin to normal. Such animals were then resistant to the further development of worms in their intestines in spite of further exposure to infection. They continued, however, to harbor low grade infestations. The expulsion of worms seemed to be produced by a host reaction which was a response to the repeated infections and served to protect the host by eliminating the excessive number of worms and by preventing others from colonizing the intestine.

Stoll (1929) was the first to clearly demonstrate this type of host reaction in helminths in his studies of sheep exposed to repeated infection with *Haemonchus contortus*. He called it a "self cure" and stressed the immunity to further infection which followed. This "self cure" phenomenon, which might perhaps be called a host protective reaction.

* From the Department of Helminthology, School of Hygiene and Public Health, the Johns Hopkins University. This work was made possible by the aid of the International Health Division of the Rockefeller Foundation.

has also been demonstrated in infections with a trichostrongylid in rabbits by Sarles (1930 and 1932), in *Nippostrongylus muris* in rats by Africa (1931), and in *Heterakis spumosa* in rats by Winfield (1933). These findings suggest that this kind of an immunity reaction is common in the relation of hosts to helminth infestations, and represents a fundamental response which serves to regulate in the face of constant reinfection the size of infestations and to protect the hosts against injury from the parasites. Such reactions would perhaps account for the fact that usually among wild animals under natural conditions, in spite of the enormous production of eggs and larval stages by their parasitic worms and very effective adaptations for transmission, most individuals tend to harbor only limited numbers of worms and to show comparatively little effect from their presence. It is evident that in certain cases in nature or in experiments susceptible animals receive such overwhelming doses of parasitic worms that the protective mechanism fails to regulate the infestation and they succumb to its effects. Thus a puppy can be readily killed by too large numbers of the larvae of *Ancylostoma caninum*, whether given in single or repeated doses. This kind of parasitism leads to acute fatal disease, in which the protective reaction fails to overcome the overwhelming infection.

On the other hand it has been shown that in certain cases the resistance of a host can be broken down so that it will become susceptible to infection. In a recent series of studies by Foster and Cort (1931 and 1932) it was found that dogs which on account of age and previous infections had developed such a resistance to *A. caninum* that even enormous doses of larvae failed to produce infestation, became after subjection for a considerable period to a deficient diet as susceptible as they had been when first infected as puppies. When the dogs that had been heavily infested while on the deficient diet were returned to an adequate diet, they quickly threw off their worm burdens and again became resistant. In certain cases when they were continued on the poor diet and repeatedly infected they finally died from hookworm disease. In these cases the mechanism of resistance was broken down by the deficient diet which drastically reduced the vitality of the host. Some evidence also is available that repeated bleeding of resistant animals will break down the protective mechanism against parasitic worms (Ackert and Porter, 1931, and Porter and Ackert, 1933). It seems possible also that further investigations will show that other conditions which reduce the vitality of the host, such as bacterial or protozoan diseases, infections with other parasitic worms, or poisons will disturb this mechanism of resistance and make immune animals susceptible. The mechanism of this resistance remains to be worked

out, and many further studies need to be made on the relation of a variety of helminths to the hosts before its action can in any way be adequately understood.

Turning from the reactions against the parasite to the disease produced in the host it is possible to analyze the effects of *Ancylostoma caninum* on dogs into several types of hookworm disease between which of course there are various intergrades. The first type which might be separated out is the fatal acute hookworm disease produced in susceptible puppies by either heavy single or repeated infections. This type is easily produced experimentally and must occur naturally under unusual conditions of exposure to infection. It has recently been shown by Foster (1932) that this type of hookworm disease can be produced in very young puppies by prenatal infection. The second type would be the acute hookworm disease produced in susceptible puppies which may cause severe anemia but from which the animals are able to recover on account of the development of the protective mechanism which eliminates most of the worms and produces resistance to further infection. As a third type might be considered the chronic infestations which occur in animals that have developed a resistance and, in spite of repeated exposure to infection, harbor only a few worms. The effects of the worms in such cases are completely or almost completely compensated for. To this type belong the infestations carried by experimental animals that have developed an age resistance or have a history of previous heavy infestation and acute disease from which they recovered. Most of the natural hookworm infestations in dogs brought into the laboratory are of this type. Puppies repeatedly subjected to light infections might from an early age carry a small worm burden and develop a resistance without ever showing symptoms of hookworm disease. In dogs which almost always become much more resistant to hookworm infection as they grow older it is impossible to separate the age resistance from that produced by previous infections. The fourth type is the severe hookworm disease that can be produced in resistant animals after they have been made susceptible to infection by some condition that will break down the resistance. This type of disease was produced by Foster and Cort (1931 and 1932) in the resistant dogs which were placed on an inadequate diet. This type may be fatal if the condition that breaks the resistance is drastic or long continued enough. In other cases the return to an adequate diet produced a loss of worms and a recovery from the disease symptoms. It seems very probable that a long continued chronic hookworm disease would be caused in such animals by conditions that would only partly break the resistance or by the acquisition of only a moderate instead of heavy infestations by non-resistant animals. It is of course evident that the above analysis is much too simple to cover the actual variations

that occur, and that it is to a considerable extent speculative since further researches are needed on all the factors involved.

In spite of these limitations in our knowledge the temptation to speculate along these same lines on human hookworm disease is too tempting to resist. Several years ago I had the opportunity of discussing with the late Samuel T. Darling many of the problems of hookworm disease. One point that Darling always stressed was the moderate infestations often found in many individuals and the small proportion of severe disease in most hookworm infested populations in spite of a very great exposure to infection. He stated that he could see no other possible explanation for these facts than that there must be developed an acquired immunity which protected the host in most cases from the acquisition of overwhelming worm burdens. It seems very probable from information on the prevalence of ground itch and the extraordinary numbers of hookworm larvae that can be found in places visited by hookworm infested populations, that constant penetration of larvae through the skin occurs. In other words almost any infested population living under insanitary conditions is constantly exposed to an amount of infection with hookworm larvae that in the absence of any host resistance would be expected to produce in the exposed individuals constantly increasing worm burdens that would finally produce fatal disease. The fact is that deaths from uncomplicated hookworm infestation are comparatively rare. There seems to be no evidence that in man age *per se* is a factor. The great body of experience with human hookworm infestations and disease is against this view. We also have records of several experimental infections of adults who had never been previously exposed in which a large proportion of the infective larvae used developed to maturity. This also indicates that in susceptible individuals there may be no very great loss of the larvae which enter the host. This relation is well illustrated in puppies in which from 30 to 80 per cent of the larvae of the dog hookworm used in infection will usually develop to sexual maturity in the intestine. All these facts point to the development of a host protective reaction in man to hookworms similar to that known in the host-parasite relations of the nematodes mentioned above that have been studied experimentally.

If such a resistance be postulated it would explain the relatively moderate infestations and slight evidence of hookworm disease found in many individuals and groups of people living under conditions where the lack of sanitation would seem to produce situations very suitable for the dissemination of hookworms. There are present, however, in all but very lightly infested groups a certain proportion of the population that show very much heavier infestations than the average and suffer from severe hookworm disease. The usual view that such in-

dividuals have been more exposed to infection than the rest of the population is almost always incapable either of proof or disproof. In certain countries, too, as in Puerto Rico, large groups of people appear to suffer unusually from hookworm disease. If we accept as a working hypothesis the idea of an acquired immunity in man produced by exposure to infection with hookworms, the unusually heavy infestations and clinical disease of certain individuals or population groups might be explained on the basis of complicating factors that serve to reduce or break down the resistance.

It seems probable, therefore, that the level of equilibrium of hookworm infestation established in a population group is determined by an interaction between the extent to which infective larvae can develop and penetrate into the human host under the influence of environmental conditions and the extent to which the resistance of the hosts can be built up. The first factor depends on climate, soil and sanitation and the second on the health and vitality of the individuals in the group. In regions like Australia or Shantung province in China an extensive subclinical hookworm infestation is present under conditions of poor sanitation but unfavorable climatic conditions. In these and similar areas it is probable that the adverse temperature and moisture conditions which prevent the building up of any considerable soil infestation are chiefly responsible for the low level of infestation. Even in such situations the development of host resistance probably has a part. Where the infestation is comparatively low in spite of soil pollution habits and favorable soil and climatic conditions, it seems probable that the development of host resistance is the chief determining factor. If such a group were in general well nourished and relatively free from various debilitating factors, most of the individuals would be expected to carry low grade infestations. Heavy infestation and severe hookworm disease might be produced by accidental exposure to massive infection of children or others in the population in whom resistance had not had a chance to develop. Clinical hookworm disease produced by heavy worm burdens would also develop in individuals whose resistance had been broken down after it had been acquired or who had never been able to develop resistance on account of undernourishment or other debilitating factors. The highest level of infestation and the severest clinical hookworm disease would be expected in undernourished or otherwise debilitated populations where environmental conditions and human habits were favorable for the dissemination of hookworms. The severity of hookworm disease in certain areas of Puerto Rico where the people are badly undernourished supports this view.

It seems possible, indeed, that the extent of heavy hookworm infestation and severe hookworm disease may depend as much in a

given population group on the prevalence of undernourishment or other factors that weaken the health as on the lack of sanitation. If this be really true, then the improvement of the general health of a group by correcting undernourishment or eliminating chronic malaria or other debilitating factors might be as important a measure for the control of hookworm disease as the improvement of sanitation alone. This emphasizes the importance of combining with treatment to reduce the worm burden of a group suffering from hookworm disease other measures that will improve their general health and eliminate undernourishment. This view cannot be considered as an argument against the attempt to improve sanitation in hookworm infested communities but only as an emphasis on the need of combining in the program for control all remedial measures possible to improve the general health of the population. Many further studies are needed both on experimental animals and human hookworm infestations before the view just expressed can be considered as anything but a working hypothesis. It seems to me possible, however, that the picture here presented may be the more correct one and that some of the present views on hookworm disease and its control will have to be radically changed when more consideration has been given to the part taken by the reactions of the host against the parasite.

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IN MEMORIAM

Joseph Leidy, Jr. (1867–1932)

Dr. Joseph Leidy, Jr., who died July 6, 1932, was born April 11, 1867. He was the son of Dr. and Mrs. Philip Leidy, of Philadelphia. As a physician, Dr. Leidy held many important posts and received many honors both at home and abroad. His chief contribution to the field of parasitology was the volume which he edited, entitled, "Researches in Helminthology and Parasitology." This was a collection of scattered papers mostly on parasitology, and a bibliography, representing the work of his uncle, Professor Joseph Leidy, the great naturalist. Dr. Leidy's fine personality will be missed by all who had the good fortune to know him.

Louis Schapiro (1886–1932)

Dr. Louis Schapiro, who died in Siam on February 4, 1932, was born in Poland, May 24, 1886. He came to the United States with his family when he was four years old. Dr. Schapiro's work in the field of parasitology started in the Philippine Islands and was continued when he became connected with the International Health Division of the Rockefeller Foundation in 1914. He served as a field director for this organization in Costa Rica, Panama and Siam. His efforts were largely given to the development of programs for the control of hookworm disease in these countries. The development of the Public Health Departments in Costa Rica and Panama were also largely due to his efforts. Dr. Schapiro approached his problems from the research point of view and found time in the midst of his busy administrative routine to publish a number of papers on various phases of the hookworm problem. His administrative ability and tact particularly fitted him for his chosen work and he was very successful in gaining the cooperation of the groups with which he dealt. His many friends in the countries in which he worked and in the United States will long remember him for his friendliness, his pleasing personality and unbounded enthusiasm.

REVIEWS AND NOTES

LEHRBUCH DER HELMINTHOLOGIE. Eine Naturgeschichte der in deutschen Säugetieren und Vögeln schmarotzenden Würmer, unter besonderer Berücksichtigung der Helminthen des Menschen, der Haustiere und wichtigsten Nutztiere. By Dr. Curt E. W. Sprehn. Verlag von Gebrüder Borntraeger, Berlin.

This latest addition to manuals in parasitology is impressive in size and compass. Limited by title to the field of helminthology it treats of Trematoda, Cestoda, Nematoda and Acanthocephala in more extensive manner than any other work available, and to these adds a brief section on Pentastomida which is designated as Class V. Although for practical purposes it is convenient to consider the last named group in series with the preceding, yet few zoologists would approve of the author's system in which it is given as an appendix to the Phylum Vermes.

The book embraces 998 pages with 374 illustrations. It opens with a few pages of general discussion, considers at greater length the structure, life history and biology of each of the five classes already named, and then treats of helminthological diseases, the method of technic already developed for the study of helminths, and closes this section with a brief survey of the history of the subject. Then follows a section on the special natural history of the helminths, to which nearly two thirds of the volume are devoted. Each class is analyzed into its various subdivisions and keys are given as well as a diagnosis for each subdivision; under each genus and species one finds the synonyms listed, a brief diagnosis, a record of the reported hosts and of the geographic distribution and a list of numbers referring to the literature on this particular item.

Following these special sections devoted to each of the five classes in order, is an extended record of the mammals and birds falling within the scope of the work with lists of parasites reported for each species. This covers 90 pages and is apparently complete for Central Europe with some records for America and Asia that are far from inclusive. An alphabetic list of genera and species follows with synonyms and references to the places where data on each may be found in the text. A long list of the literature referred to in the volume and including 1253 items terminates the work. The author has brought together a vast amount of material and has organized it well so that the student can easily find any desired item. To hold the topic within limits some selection was probably necessary and one can not well object to the choice which the author has exercised although it is difficult to see on what basis the extra-European forms were selected.

The list of literature is strangely composed. It appears to contain every paper of certain authors whereas significant contributions by others are not included and some important writers are not mentioned. In this respect casual inspection of the list showed impartial omission of French, Japanese, and American students, both old and young. Most striking is the omission of the Author Catalogue by Stiles and Hassall, a publication widely known and considered indispensable by researchers in this field.

Two pages are necessary for the *Corrigenda* and the list is far from complete. Rapid reading caught two score other errors in spelling, elision of words, etc., to say nothing of faulty punctuation. These slips are most numerous in the closing sections of the book and suggest poor proof reading or too great haste in handling that portion of the work. Most of the figures are good but the photographs are far inferior to the drawings and some of them (e.g., Figs. 122, 123, 147) are really worthless. The use of photographs of models is hardly to be approved, especially when better cuts of the actual objects are readily available.

But these are not the major fault in the work. Although the first lines of the preface emphasize the special relation of this volume to medical helminthology, almost nothing is included of the new lines of study so brilliantly developed

by Fülleborn and the Hamburg school, by Brumpt and his confrères in Paris, or by the Johns Hopkins group in the School of Hygiene. The extensive studies by many authors on life histories, ecology, immunity and other biological features of outstanding importance in the medical field are not even mentioned.

It is particularly unfortunate that such defects should appear in a work coming from the Institute at Leipzig where the foundations of modern parasitology were laid broad and deep by Leuckart, recognized at home as *Altmeister der Helminthologie* and acknowledged as the great leader by students in all nations. From that source one might have looked for a master work and not one that is so purely systematic and devoid of the biological emphasis that made Leuckart's teaching and writing so stimulating. Unfortunately also the publisher has fixed a price for the volume that is out of keeping with the times and the cost of other works in this field.

H. B. Ward

A NEW CANADIAN INSTITUTE OF PARASITOLOGY

Under the joint auspices of the Dominion Research Council and the Empire Marketing Board a new Canadian Institute of Parasitology, situated at Macdonald College, has been created by McGill University. A new building has been erected to house this Institute by the Quebec Government, and it has been placed under the direction of Dr. T. W. M. Cameron, who was, for ten years, Assistant to Professor R. T. Leiper at the London School of Hygiene and Tropical Medicine, and during the past three years, Lecturer in Helminthology at Edinburgh University. He will be assisted by Dr. R. L. Conklin, Professor of Animal Pathology in Macdonald College and a staff of two research assistants. The object of this new Institute is to carry out investigations on the parasites of domesticated and others animals, primarily, but not exclusively, from the economic point of view. While the parasites of Canadian animals will necessarily receive first attention, it is expected that the scope of the Institute will extend beyond the Dominion and come to have significance for the whole British Empire. While the aims of the Institute are primarily research into parasitological problems it is hoped that post-graduate students, and others interested in research along these lines, will be attracted to the Institute.

PROGRAM AND ABSTRACTS OF THE EIGHTH ANNUAL MEETING OF THE AMERICAN SOCIETY OF PARASITOLOGISTS

ATLANTIC CITY, NEW JERSEY

DECEMBER 28, 29 and 30, 1932

PROGRAM[1]

WEDNESDAY MORNING SESSION, DECEMBER 28, 10:00 A. M.; COMMITTEE ROOM 2, MUNICIPAL AUDITORIUM.

Read

1. The Resistance of European Hares and Rabbits to Superinfestation by Different Species of the Genus Cittotaenia. (7 min.) HORACE W. STUNKARD, New York University.

2. Multiple Infections of *Taenia saginata* Produced Experimentally. (10 min.) S. X. CROSS, University of Wisconsin.

3. Detection of Proteins of *Haemonchus contortus* in Sera of Infected Sheep and Goats. (15 min.) (Lantern.) JOHN E. STUMBERG, Rockefeller Institute for Medical Research, Princeton, N. J.

4. Fatal Infections of *Trichostrongylus calcaratus* in Rabbits. (15 min.) (Lantern.) MERRITT P. SARLES, Rockefeller Institute for Medical Research, Princeton, N. J.

5. Age Resistance of Chickens to the Parasite, *Ascaridia lineata*. (12 min.) (Lantern.) J. E. ACKERT, D. A. PORTER, and T. D. BEACH, Kansas State College.

6. Studies on Age-Resistance of Laboratory Rats to *Nippostrongylus muris* (Yokogawa, 1920). (15 min.) (Lantern.) GEORGE L. GRAHAM, Johns Hopkins University.

7. The Development of Natural and Artificial Resistance of Young Rats to the Parasite, *Trypanosoma lewisi*. (10 min.) (Lantern.) C. A. HERRICK, University of Wisconsin.

8. The Cellular Basis for the Action of Antitrypanosome Serum within the Body. (15 min.) (Lantern.) WILLIAM H. TALIAFERRO and L. R. KUHN, University of Chicago.

9. The Immunizing Properties of an Attenuated Strain of *Histomonas meleagridis*. (15 min.) (Lantern.) ERNEST EDWARD TYZZER, Harvard University.

10. Quantitative Studies on Oocyst Production by *Eimeria miyairii* during Immunization of Rats belonging to Different Strains. (15 min.) (Lantern.) ELERY R. BECKER and PHOEBE R. HALL, Iowa State College.

11. The Effect of Washing Cultures and of Exchanging Bacterial Flora on the Pathogenicity of *E. histolytica* for Kittens. (10 min.) (Lantern.) WILLIAM W. FRYE and HENRY E. MELENEY, Vanderbilt University.

By Title

12. Resistance to Infestation with *Trichinella spiralis* in Hogs. GEORGE W. BACHMAN and R. RODRIGUEZ-MOLINA, School of Tropical Medicine, San Juan, P. R.

13. Pathogenicity of Metacercariae of *Nanophyetus salmincola*, Chapin, for Fish Hosts. B. T. SIMMS, Oregon Agricultural Experiment Station.

14. Oxygen Capacity of Blood in Experimental Trypanosome Infections in Rats. CARL M. JOHNSON, Johns Hopkins University.

15. Immunity to Coccidiosis in Chickens, Produced by Inoculation Through the Ration. W. T. JOHNSON, Oregon State Agricultural College.

16. Effect of Fecal Extracts in *E. histolytica* Culture Media. JUSTIN ANDREWS, CARL M. JOHNSON and SEYMOUR C. SCHWARTZ, Johns Hopkins University.

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[1] An alphabetical author index will be found at the end of the program.

17. Studies on a Complement Fixation Test for Amoebiasis. H. TSUCHIYA, Washington University, St. Louis.

WEDNESDAY AFTERNOON SESSION, DECEMBER 28, 2:00 P. M.; COMMITTEE ROOM 2, MUNICIPAL AUDITORIUM.

Read

18. A New Variety of Retortomonas (Embadomonas) from Man. (10 min.) (Lantern.) M. J. HOGUE, University of Pennsylvania.

19. Further Observations on the Origin of Intestinal Lesions Associated with Infections by Balantidium and Endamoeba. (15 min.) (Lantern.) HERBERT L. RATCLIFFE, University of Pennsylvania and Zoological Society of Philadelphia.

20. Food Reactions of *Balantidium coli.* (10 min.) E. C. NELSON, Johns Hopkins University.

By Motion Pictures

21. I. The *Endamoeba histolytica* and the *Balantidium coli.* II. The Life History of the *Diphyllobothrium latum.* R. B. H. GRADWOHL, St. Louis.

Read

22. Comparative Study of *Diphyllobothrium cordiceps* and *D. latum.* (10 min.) (Also by demonstration.) MARY SCOTT SKINKER, Bureau of Animal Industry, Washington, D. C.

23. *Diphyllobothrium cordatum* (Leuckart, 1863) in Bears of Yellowstone Park, Wyoming. (15 min.) (Lantern.) (Also by demonstration.) JOHN W. SCOTT, University of Wyoming.

24. Complementary Note to my Observation on the Life History of *Moniezia expansa.* (10 min.) D. F. SINITSIN, Los Angeles.

25. Attempts to Grow Cestodes *in vitro.* (8 min.) HORACE W. STUNKARD, New York University.

26. The Effect of Soil Types on Helminthic Parasites of a Lizard, *Leiolopisma laterale.* (15 min.) (Lantern.) (Charts.) PAUL D. HARWOOD, Vanderbilt University.

27. The Sedimentation Method in the Diagnosis of Schistosomiasis mansoni. (10 min.) W. A. HOFFMAN and J. A. PONS, School of Tropical Medicine, San Juan, P. R.

28. The Life History of *Troglotrema mustelae* n. sp. (8 min.) (Lantern.) (Also by demonstration.) F. G. WALLACE, University of Minnesota.

By Title

29. Amphibian Parasites of the Orders Strongyloidea, Dioctophymoidea and Trichinelloidea (Nematoda). A. C. WALTON, Knox College.

30. The Germ Cell Cycle in Trematodes. ARTHUR E. WOODHEAD, University of Michigan.

31. The Lymph System of *Zygocotyle lunatum,* with a Note on the Sub-family Zygocotylinae. CHARLES H. WILLEY, New York University.

32. *Cercaria sphaerula* n. sp. Infesting Cyclops. LYELL J. THOMAS, University of Illinois.

33. Studies on the Development of *Cercaria bessiae* Cort and Brooks, 1928. WENDELL H. KRULL, U. S. Bureau of Animal Industry, Washington, D. C.

34. Studies on the Life History of *Cotylophoron cotylophorum* (Fischoeder, 1901), Stiles and Goldberger, 1910. WENDELL H. KRULL, U. S. Bureau of Animal Industry, Washington, D. C.

35. The Life History of the Human Intestinal Fluke, *Euparyphium ilocanum* (Garrison, 1908). MARCOS A. TUBANGUI, Bureau of Science, Manila, P. I.

36. Some new Trematodes of the Family Heterophyidae. E. W. PRICE, U. S. Bureau of Animal Industry, Washington, D. C.

WEDNESDAY EVENING PARASITOLOGISTS' DINNER, DECEMBER 28, 6:30 P. M.; HOTEL CHELSEA.

All interested in parasitology are cordially invited.

The annual business meeting of the American Society of Parasitologists will be held following the dinner.

THURSDAY MORNING SESSION, DECEMBER 29, 10:00 A. M.; COMMITTEE ROOM 2, MUNICIPAL AUDITORIUM.

Read

37. The Development of Strongyloides in the Experimental Host. (12 min.) (Lantern.) ERNEST CARROLL FAUST, Tulane University.

38. The Basic Plan of the Nervous System of Nematodes. (10 min.) (Lantern.) B. G. CHITWOOD, U. S. Bureau of Animal Industry, Washington, D. C.

39. The Value of Head Characters in Nematode Taxonomy and Relationship. (12 min.) (Lantern.) (Also by demonstration.) B. G. CHITWOOD and EVERETT E. WEHR, U. S. Bureau of Animal Industry, Washington, D. C.

40. On a Nematode Parasite in the Brittle Star, *Ophiocten amitinum* Lyman. (15 min.) (Lantern.) HENRY B. WARD, University of Illinois.

41. Ciliates from Sea Urchins. (12 min.) (Lantern.) PHILIP B. A. POWERS, University of Pennsylvania.

42. Studies on the Gregarines of the Oligochaeta. (15 min.) (Lantern.) (Also by demonstration.) RAPHAEL A. TROISI, University of Pennsylvania.

43. Notes on Myxosporidia. (10 min.) R. R. KUDO, University of Illinois.

44. *Trichomonas muris*, Parasitic in Oxyurids of the White Mouse. (15 min.) (Lantern.) HANS THEILER and SEYMOUR M. FARBER, Harvard University.

45. Seasonal Incidence and Concentrations of Sand Fly Larvae in Salt Marshes (Culicoides). (15 min.) (Lantern.) J. B. HULL, W. E. DOVE and D. G. HALL, U. S. Bureau of Entomology, Savannah, Ga.

46. Production of Sterile Maggots for Surgical Use. II. Disinfection with Sodium Hydroxide Followed by Formalin. (15 min.) (Lantern.) (Also by demonstration.) G. F. WHITE, U. S. Bureau of Entomology, Washington, D. C.

By Title

47. A New Filarid from the Abdominal Cavity of a Bat. ALLEN MCINTOSH, U. S. Bureau of Animal Industry, Washington, D. C.

48. The Life History of a Trichostrongyle, Longistriata sp., Parasitic in Mice. BENJAMIN SCHWARTZ and JOSEPH E. ALICATA, U. S. Bureau of Animal Industry, Washington, D. C.

49. A Review of the Taxonomy in the Genus Onchocerca Diesing (Filariidae). J. H. SANDGROUND, Harvard University.

50. The Anatomy of *Troglodytella abrassarti*. W. W. SWEZEY, Johns Hopkins University.

51. The Description of the Larva of *Anopheles atropos* Dyar and Knab, with Biological Notes on the Species. E. HAROLD HINMAN, Tulane University.

52. Comparative Study of Acariasis of the White Rat (*Rattus norvegicus* form *albinus*). LOUIS V. SKIDMORE, University of Nebraska.

THURSDAY AFTERNOON SESSION, DECEMBER 29, 2:00 P. M.; COMMITTEE ROOM 2, MUNICIPAL AUDITORIUM.

Read

53. Is Parasitology a Science? MAURICE C. HALL, U. S. Bureau of Animal Industry, Washington, D. C. (This paper is the presidential address.)

THURSDAY AFTERNOON SESSION, DECEMBER 29, 3:00 P. M.; COMMITTEE ROOM 3, MUNICIPAL AUDITORIUM.

54. The Intestinal Protozoa of the Larvae of the Crane Fly, *Tipula abdominalis*. (Demonstration.) QUENTIN M. GEIMAN, University of Pennsylvania.

55. Culture of Certain Protozoa, Bacteria-free. (Demonstration.) R. W. Glaser, Rockefeller Institute for Medical Research, Princeton, N. J.

56. Culture of a Parasitic Nematode. (Demonstration.) R. W. Glaser, Rockefeller Institute for Medical Research, Princeton, N. J.

57. Two New Cystocercous Cercariae from Alabama. (Demonstration.) Septima Smith, University of Alabama.

58. A Species of Cephalogonimous from the Domestic Duck. (Demonstration.) Clifford H. Alvey, New York University.

59. *Clinostomum attenuatum* from the Great Blue Heron. (Demonstration.) Clifford H. Alvey and Horace W. Stunkard, New York University.

There will also be demonstrations supplementary to papers presented at other times in the program.

The annual Parasitologists' tea will be held during the demonstration period.

Friday Morning Session, December 30, 10:00 A. M.; Committee Room 2, Municipal Auditorium.

Read

60. Ticks in Relation to Certain Diseases of Man and Animals. (12 min.) (Lantern.) F. C. Bishopp, U. S. Bureau of Entomology, Washington, D. C.

61. Effects of Quick Freezing upon Infective Larvae of *Trichinella spiralis*. (12 min.) (Lantern.) Donald L. Augustine, Harvard University.

62. The Occurrence of *Microfilaria ozzardi* in Panama. (12 min.) (Lantern.) O. R. McCoy, University of Rochester.

63. Results of a Protozoological Survey of 401 College Freshmen. (15 min.) (Lantern.) D. H. Wenrich, R. M. Stabler and J. H. Arnett, University of Pennsylvania.

64. Comparative Studies of Intestinal Protozoa in Different Species of Monkeys. (15 min.) (Lantern.) Robert Hegner, Johns Hopkins University.

65. The Behavior of the Avian Malarias in the Common Fowl, an Abnormal Host. (15 min.) (Lantern.) Reginald D. Manwell, Syracuse University.

66. The Control of *Leucocytozoon anatis* Wickware. (12 min.) Earl C. O'Roke, University of Michigan.

67. Control of Poultry Coccidiosis by Chemical Treatment of Litter. (15 min.) (Charts.) Justin Andrews, Johns Hopkins University.

68. Diurnal Periodicity in the Oocyst-production of the Sparrow Isospora. (15 min.) (Lantern.) Donald C. Boughton, Johns Hopkins University.

69. An Analysis of the Cyst Count of *Endamoeba coli* in a Measured Amount of Feces from Each of 431 Consecutive Stools. (15 min.) (Lantern.) Robert M. Stabler, University of Pennsylvania.

By Title

70. Observations on the Protozoan Infestations of American Indian Children in the United States. William B. Owen, Ralph F. Honess and James R. Simon, University of Wyoming.

71. Relapse and Associated Phenomena in the Haemoproteus Infection of the Pigeon. G. Robert Coatney, Nebraska Wesleyan University.

72. The Influence of an Increased Burden of Phagocytosis upon Malarial Infections of Birds. Wendell Gingrich, University of Texas, Galveston.

73. The Cytology of *Leucocytozoon anatis* Wickware. I. Gametogenesis. Rex K. Martin, University of Michigan.

74. Post-treatment Infestation with Ascaris and Hookworm in Kentucky. G. F. Otto and W. W. Cort, Johns Hopkins University.

75. Additional Observations on the Use of Fouadin in the Treatment of *Dirofilaria immitis* Infestation in the Dog. Paul C. Underwood and Willard H. Wright, U. S. Bureau of Animal Industry, Washington, D. C.

76. Studies of Bovine Coccidiosis. Charles W. Rees, U. S. Bureau of Animal Industry, Jeanerette, La.

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ABSTRACTS

An alphabetical author index, of all persons contributing to the program, just precedes.

1. The Resistance of European Hares and Rabbits to Superinfestation by Different Species of the Genus Cittotaenia. (7 min.) HORACE W. STUNKARD, New York University.

European hares and rabbits harbor the three species *Cittotaenia pectinata, C. ctenoides,* and *C. denticulata.* Records of over 1000 dissections, made by Riehm (1881), John (1926) and the writer are analyzed. Mature worms of two species of Cittotaenia have never been found together in the same intestine. The opportunity for double infection is present, since mature worms of one species and very small specimens of another have been discovered; also immature worms of two different species. Mature specimens of Cittotaenia are often present with mature specimens of Andrya sp. *C. denticulata* occurs in rabbits on the continent and in Wales. One, more often two, but never more than two adult worms are present in one animal. John reported 37 young *C. denticulata* of various ages in one rabbit and I have found as many as 150. Like *C. denticulata,* mature specimens of *C. ctenoides* occur singly or in pairs, although many young worms and sometimes one or two half-grown specimens may be present. Forty to fifty mature *C. pectinata* on the other hand, together with a greater number of young worms have been found in a single rabbit. These data, from naturally infected animals, indicate that a host which harbors one species of Cittotaenia is refractory to infection by another, and that there is a differential degree of resistance to superinfestation by the three species of Cittotaenia.

2. Multiple Infections of Taenia saginata *Produced Experimentally.* (10 min.) S. X. CROSS, University of Wisconsin.

When 3 cysticerci of the tapeworm *T. saginata* were swallowed by adult human subjects, 3 mature worms developed in each host. The worms ranged in size from 5 to 8 meters and produced gravid proglottids after 10 weeks. One worm developed to a length of 2 meters with 287 proglottids in a period of 30 days. Two segments with double genital pores and one segment with four ovaries were found in one of the worms. Studies on the metabolism and the blood picture of three experimentally infested subjects now in progress will be reported.

3. Detection of Proteins of Haemonchus contortus *in Sera of Infected Sheep and Goats.* (15 min.) (Lantern.) JOHN E. STUMBERG, Rockefeller Institute for Medical Research, Princeton, N. J.

By means of what is essentially an anaphylactic test, Haemonchus protein was detectable in dilution of 1 : 50,000. The test consisted of a rise in relative percentage of the eosinophilic leucocytes in the circulating blood following injection of extract into sensitized guinea pigs. Injection of anti-Haemonchus immune rabbit serum into unsensitized guinea pigs previously injected with Haemonchus extract caused a rise in percentage of eosinophils as long as seventeen days after injection of extract. Sera of Haemonchus-infected sheep and goats intraperitoneally injected into actively or passively sensitized and control guinea pigs caused an occasional rise in relative percentage of eosinophils in controls, and always caused a greater rise in sensitized guinea pigs. Sera of a helminth-free sheep, of a sheep infected with nematodes other than Haemonchus, and of a sheep following loss of Haemonchus infection, failed to cause a rise in percentage of eosinophils in sensitized and control guinea pigs. Serum of infected sheep caused a rise in eosinophils in guinea pigs when injected before, simultaneously with, or after an equal amount of anti-Haemonchus immune rabbit serum. Injection of immune rabbit serum into unsensitized guinea pigs previously injected with serum of an infected sheep caused a rise in eosinophils up to the twelfth day but not on

the fifteenth. Dilution of serum of infected sheep decreased its power of stimulating the eosinophil rise. The conclusion is drawn that Haemonchus protein is absorbed from the alimentary tract sufficiently unaltered to react with specific antibodies in an anaphylactic test.

4. Fatal Infections of Trichostrongylus calcaratus *in Rabbits.* (15 min.) (Lantern.) MERRITT P. SARLES, Rockefeller Institute for Medical Research, Princeton, N. J.

Laboratory rabbits were infected with *T. calcaratus* larvae in single doses of different sizes, with increasing weekly doses, and by exposure to natural reinfection outdoors. The parasitic infections were followed by frequent egg counts and condition of rabbits by record of weight, consistency of feces, appetite, and appearance. According to their size, single oral doses of larvae produced infections which (a) had no effect on the weight curve, (b) retarded gain in weight, or (c) caused loss of weight and finally death. Weekly increasing doses of larvae produced infections which (a) were without effect on weight, due apparently to successful intervention of the self-cure phenomenon, (b) caused only temporary loss of weight, evidently due to acquirement of resistance to superimposed infection with or without subsequent self-cure, or (c) caused gradual loss of weight ending in death, in hosts which were apparently attempting to discharge their worms when they died. While exposure to natural reinfection outdoors produced small infections in resistant animals which were without effect on weight, it established a heavy infection in one previously uninfected rabbit which died following prolonged loss of weight. In fatal infections loss of weight was associated with failing appetite, and the chronic course of infection involved progressive emaciation, frequent passage of soft fecal pellets and liquid feces, weakness, prostration, and death. Although rabbits dying of *T. calcaratus* infection always harbored more than 1000 worms, gross lesions at autopsy were negative except for evidences of extreme emaciation.

5. Age Resistance of Chickens to the Parasite, Ascaridia lineata. (12 min.) (Lantern.) J. E. ACKERT, D. A. PORTER and T. D. BEACH, Kansas State College.

Results of studies made in recent years on 449 chickens showed that as young chickens advanced in age (up to about 100 days) their resistance to the growth of the intestinal nematode, *Ascaridia lineata,* increased. The chickens were raised in confinement on an adequate diet and were kept free from helminths until the beginning of the experiment. The chickens of each group were of the same age and were parasitized with the same number of *A. lineata* eggs. In all cases the period of parasitism was three weeks. The criterion for determining the degree of resistance was the mean length of the *A. lineata* from the group of chickens in question.

From feeding 300 *A. lineata* eggs to each chicken results were obtained as follows: Chickens parasitized when 45 days old yielded nematodes averaging 21.19 mm. in length; those parasitized at 63 days gave worms with a mean length of 16.10 mm.; a third group given embryonated worm eggs at 71 days of age yielded *A. lineata* averaging 11.96 mm. and a fourth group parasitized when 93 days old gave worms with a mean length of 3.93 mm. The differences in average lengths of the *A. lineata* from these successive groups were significant, showing that as white leghorn chickens advanced from 45 to 93 days of age, their resistance to the growth of the *A. lineata* increased. This resistance is attributed to the natural development of a growth inhibiting factor.

6. Studies on Age-Resistance of Laboratory Rats to Nippostrongylus muris (*Yokogawa, 1920*). (15 min.) (Lantern.) GEORGE L. GRAHAM, Johns Hopkins University.

Two experiments have yielded interesting information concerning this phenomenon. The first involved two groups of four rats, 6 and 14 weeks old respectively. Individuals in each group were given dermal infections of 110, 105, 115,

100 and 725 infective larvae, each infection being at two-day intervals. Total fecal output of each group was used for 24-hour (later 48-hour) samples for modified Stoll dilution egg counts. The older group reached a peak of 57,500 eggs per day per rat on the 11th day after infection; at which time the younger group showed a production of 68,250 eggs. The latter however attained a peak egg production of 207,500 eggs on the 17th day and then rapidly declined. Difference in egg production appeared due to age since both groups received the same number of infective larvae. The second experiment involved one group of seven rats, 12 months, and another group of 11 rats, six weeks old. They were each infected dermally with 400 infective larvae and examined for worms 12 days later. The older group yielded an average of 113 mature worms per rat and the young group 112 worms, the latter not visibly different in size from the former. If one uses this criterion, *i.e.,* percentage development, the only conclusion possible is that no age resistance is shown.

Since strain modification can be dismissed from consideration, it appears that egg production is a much more delicate criterion than percentage development or growth rate in this particular relationship.

7. The Development of Natural and Artificial Resistance of Young Rats to the Parasite, Trypanosoma lewisi. (10 min.) (Lantern.) C. A. Herrick, University of Wisconsin.

Studies were made on two strains of *T. lewisi* in 14 groups of rats over a period of more than a year. It was found that the mortality rate of weaned rats infected with *T. lewisi* when 20 days old, was over 80 per cent. As the age of the rats increased the mortality decreased until 40 days old when there was no mortality among the infected rats. When the 20 day old weaned rats were given intramuscular pituitary implants from adult rats every second day for two weeks they did not die as did the litter-mate controls when infected. Subcutaneous injections of the ovarian hormone, theelin, into the 20 day old weaned rats increased their resistance to the pathogenic effects of the parasite *Trypanosoma lewisi.*

8. The Cellular Basis for the Action of Antitrypanosome Serum within the Body. (15 min.) (Lantern.) William H. Taliaferro and L. R. Kuhn, University of Chicago.

Mice are protected from infection with *Trypanosoma equiperdum* when given trypanosomes together with immune serum derived from sheep during a sub-acute infection in doses of 0.3 cc. of serum per 20 gm. mouse. On the other hand, control mice, *i.e.,* untreated with immune serum but infected with *T. equiperdum,* die in about seven days. When such immune serum is tested in splenectomized mice, variable results are obtained. In some cases, the serum protects, but in other cases, doses ranging up to 0.5 cc. do not protect. In marked contrast to these results, immune serum loses its highly protective action in mice which have been splenectomized and blockaded with India ink, *i.e.,* given daily injections of 1.0 cc. of 7 per cent India ink. Thus, blockaded and splenectomized mice, when given trypanosomes together with doses of immune serum as high as 1.7 cc. per 20 gm. mouse, live a few days longer than controls, but eventually die with a progressive acute trypanosome infection. Immune serum is similarly ineffective when mice are splenectomized and blockaded with normal sheep serum.

These results indicate that, although immune serum *in vitro* is trypanocidal, *in vivo* it depends upon some intermediary system, probably the macrophage or reticulo-endothelial system, of the mouse. Trypanocidal drugs and normal serum previously had been found to act similarly.

9. The Immunizing Properties of an Attenuated Strain of Histomonas meleagridis. (15 min.) (Lantern.) Ernest Edward Tyzzer, Harvard University.

A strain of Histomonas originally pathogenic for chickens as well as for turkeys has lost its virulence under long cultivation. Infection with this strain

furnishes a high degree of protection, not only in chickens, as already reported, but also in turkeys against fully virulent strains of Histomonas. The immunity which develops promptly, as early as a fortnight after the initial inoculation, may be lost to some extent in later life, probably in consequence of loss of the infection. Such cases of clinical blackhead in growing turkeys that have been vaccinated at an early age are characterized by a high percentage of prompt recoveries. The greatest freedom from the disease is encountered in those groups of birds that, following vaccination, are most continuously exposed to infection. The only assurance of the success of the vaccination inoculation is the appearance of the specific protozoan in the caecal discharge.

10. Quantitative Studies on Oocyst Production by Eimeria miyairii *during Immunization of Rats belonging to Different Strains.* (15 min.) (Lantern.) ELERY R. BECKER and PHOEBE R. HALL, Iowa State College.

The writers recently reported on the great individual variability in susceptibility to coccidial infection, as measured by oocyst production, which they found among white rats. The present study was made to determine the extent of this variability in susceptibility within individual litters, and to ascertain whether the susceptibility is inheritable. The experimental rats were six weeks of age at the time of the first infective feeding of sporulated oocysts, and were on a modified Steenbock ration. The strain designations and mean oocyst counts (in terms of 10^6) were as follows: "Lo strain," 24 rats, 70.2; "Hi strain," 37 rats, 188.5; "Lambert strain," 15 rats, 34.1; Wistar Experimental Laboratory strain, 18 rats, 78.0; "Wistar A" strain, brother and sister inbred for 58–59 generations, 13 rats, 153.1. The counts for the W. E. L. strain ranged from 27 to 160, and were the most variable. Those for the "Wistar A" strain ranged from 77 to 205, and were the least variable. The experiments indicate definitely that the susceptibility of rats to coccidiosis has a genetic basis.

11. The Effect of Washing Cultures and of Exchanging Bacterial Flora on the Pathogenicity of E. histolytica *for Kittens.* (10 min.) (Lantern.) WILLIAM W. FRYE and HENRY E. MELENEY, Vanderbilt University.

Cultures of *E. histolytica* from two acute cases of amoebic dysentery in West Tennessee produced a higher incidence of infection in kittens and a more intense pathology than did cultures from two carriers in the hills of eastern Tennessee. (In press.) We have attempted, therefore, to determine the importance of the bacteria in these cultures as factors in the difference in pathogenicity. The bacteria alone from the four strains produced no pathology when inoculated directly into the ileum of kittens. When the amoebae from one acute strain were washed as free as possible from the culture bacteria and then inoculated into kittens the incidence of infection was much lower than with unwashed cultures. The washed cultures were controlled for viability. When washed amoebae from this acute strain were mixed with bacteria from a carrier strain they produced as high an incidence and intensity of infection as they had with their own bacteria. When washed amoebae from the carrier strain were mixed with bacteria from the acute strain they did not produce a higher incidence or more intense pathology than they had with their own bacteria. These observations seem to indicate that the difference in pathogenicity shown by these strains of *E. histolytica* was a property of the amoebae themselves and not of the bacteria accompanying them in culture. However, removing most of the bacteria with which the amoebae had been growing, and not substituting other bacteria before inoculation, seemed to lessen the ability of the amoebae to produce lesions in the inoculated kittens.

12. Resistance to Infestation with Trichinella spiralis *in Hogs.* (By Title.) GEORGE W. BACHMAN and R. RODRIGUEZ-MOLINA, School of Tropical Medicine, San Juan, P. R.

The purpose of this work is: First, to determine the comparison between antibody production and eosinophilia, as result of primary and subsequent infestations

with this parasite; second, to determine the effect of immunization upon antibody production and eosinophilia; third, to determine the resistance established in hogs convalescing from trichiniasis; fourth, to determine the nature and mechanism of such resistance. Total leucocyte counts, differentials, precipitation tests, and estimation of hemoglobin percentages were done in ten young hogs for 345 days, at five day intervals. Animals were fed 500–600 grams of trichinous meat every eighty days, the percentage of eosinophiles and precipitin titers being recorded during each period of infestation. Biopsies were performed previous to each feeding and average number of larvae in twenty to thirty microscopic fields was determined. In the five animals that survived there were a decided eosinophilia (highest 32 per cent) and high precipitin titer (1 in 6000) during first infestation, but a rapid decrease and total absence of same during subsequent infestations. Convalescence during repeated infestation was not correlated with high eosinophilia and precipitin titer. Immunization with intramuscular injections of variable amounts of one per cent suspension of trichina powder in Coca's alkaline solution produced eosinophilia (16 per cent) and high titer (1 in 6000). Immunization previous to infestation afforded no protection against trichiniasis. The authors believe that the resistance to superinfestation is due to cellular activity, and that this activity is a localized one taking place during the intestinal phase of the infestation.

13. Pathogenicity of Metacercariae of Nanophyetus salmincola, *Chapin, for Fish Hosts.* (By Title.) B. T. Simms, Oregon Agricultural Experiment Station.

Heavy losses have occurred among both young rainbow trout, *Salmo irideus,* and young brook trout, *Salvelinus fontinalis,* at one of the Oregon Game Commission hatcheries. Popeye has been a prominent symptom in some of the outbreaks but not in others. The sick and dying fish have been heavily infested with metacercariae of the salmon poisoning fluke, *Nanophyetus salmincola.* Apparently healthy young fish which were heavily infested with these metacercariae have been observed in both hatcheries and western Oregon streams. The species included have been rainbow trout, cut-throat trout, *S. lewisi,* chinook salmon, *Oncorhynchus tschawytscha,* and silver salmon, *O. kisutch.* Severe infestation of both young rainbow and young brook trout as the result of laboratory exposure was not followed by either death losses or symptoms.

14. Oxygen Capacity of Blood in Experimental Trypanosome Infections in Rats. (By Title.) Carl M. Johnson, Johns Hopkins University.

Two series of experiments have shown that *Trypanosoma equiperdum* causes a marked diminution in the oxygen capacity of the blood of experimentally infected rats. Determinations made at various periods during the infection showed a progressive reduction in the ability of the blood to carry oxygen. Blood obtained at death was not capable of taking up more than 60 per cent of the maximum amount of oxygen which can be absorbed under normal conditions. It is believed that this condition can be ascribed to the interference with the oxygen-absorbing function of hemoglobin due to the progressive acidosis which has been shown to prevail.

15. Immunity to Coccidiosis in Chickens, Produced by Inoculation Through the Ration. (By Title.) W. T. Johnson, Oregon State Agricultural College.

Three pens of S. C. White Leghorns, incubator hatched May 16, 1932, were used to determine practicability of administering oocysts in wet mash to produce immunity. Group I was kept on one-inch mesh poultry netting, Groups II and III on straw litter not changed during period of feeding oocysts. Prepared with fresh feces, pure cultures of *Eimeria mitis, E. praecox, E. acervulina, E. maxima* and *E. tenella* were given between April 23 and May 15. The five species were combined and mixed with mash just before inoculation. Group I was not experimentally inoculated. Group II was inoculated daily from July 5 to 20, Group III on 23 days, June 15 to July 8. The minimum, maximum and total sporulated oocysts

given each surviving fowl in Group II (computed from one count) was 108, 111, 1638 for *E. mitis;* 269, 276, 4077 for *E. praecox;* 202, 207, 3060 for *E. acervulina;* 151, 154, 2283 for *E. maxima* and 1303, 1335, 19,737 for *E. tenella.* Group III: 93, 106, 2236; 231, 263, 5549; 173, 198, 4166; 129, 147, 3102 and 50, 907, 11,129, respectively. Group II evidenced distinct detrimental results from *E. tenella.* Distinct protection against large doses was demonstrated subsequently in Groups II and III and susceptibility in Group I, judged by character and amount of feces passed, amount of feed and water consumed, activity and general appearance, body weight, mortality rate, interval between inoculation and appearance of symptoms and numbers of oocysts in feces. Results lend encouragement to feeding sporulated oocysts in wet mash as practical means of immunization.

16. Effect of Fecal Extracts in E. histolytica *Culture Media.* (By Title.) JUSTIN ANDREWS, CARL M. JOHNSON and SEYMOUR C. SCHWARTZ, Johns Hopkins University.

These experiments show that the number of dysentery-producing amebae, *E. histolytica,* produced *in vitro* has been significantly increased by the addition of sterile or non-sterile extracts of human feces to the culture fluid. Both Tanabe's (1928) and St. John's (1932) culture media were used. Fecal extracts were prepared by diluting one volume of fresh human feces with two volumes of culture fluid. After two hours the mixture was filtered to remove all solid ingredients. In some instances the filtrate was sterilized by passage through a Berkefeld "W" filter. The filtrate was diluted with an equal quantity of culture fluid for use. From one and one-half to two times as many amebae (by count) grew in the tubes containing fecal extracts as compared with tubes without fecal extract, though all tubes were inoculated with the same number of amebae and were maintained under the same conditions.

17. Studies on a Complement Fixation Test for Amoebiasis. (By Title.) H. TSUCHIYA, Washington University, St. Louis.

The samples of feces and sera of 153 cases were examined, and of these, both feces and sera were found to be negative in 135 cases. Of 18 positives either by feces or sera, there were discrepancies in 5 instances. While the results are promising especially with the view of eliminating possibilities of amoebiasis in given cases, there still remains a doubt as to the real value of the complement fixation test in clinical diagnosis, unless carefully checked by repeated microscopic and cultural examinations of feces as well as of protoscopic materials. No apparent correlations existed between this test and the complement fixation or Kahn test for lues. As the antigen prepared for this test was sufficiently potent, its bacterial fractions did not alter the outcome of the test.

18. A New Variety of Retortomonas (Embadomonas) from Man. (10 min.) (Lantern.) M. J. HOGUE, University of Pennsylvania.

A variety of *Retortomonas intestinalis* has been grown in culture for two and a half years. The flagellate is similar in size, shape, nucleus and blepharoplasts to the type form. The two flagella are of about equal length and thickness. Cysts are formed in culture media. These cysts have a region at one end which stains black with Heidenhain's haematoxylin. This variety lives in sodium chloride sheep serum water made up with sodium chloride solutions ranging from 0.1 to 0.85 per cent. They do not live in this culture medium made up with distilled water.

19. Further Observations on the Origin of Intestinal Lesions Associated with Infections by Balantidium and Endamoeba. (15 min.) (Lantern.) HERBERT L. RATCLIFFE, University of Pennsylvania and Zoological Society of Philadelphia.

Intestinal lesions associated with infections by Balantidium or Endamoeba in man and certain lower animals are essentially similar and are present in at

least two forms: (1) superficial erosion of the mucosa by the protozoa, and (2) ulceration of lymph follices, which apparently is secondary to the first, and the result of bacterial invasion of the eroded mucous membrane. The latter constitute the undermining ulcers described as typical of these infections. Deep tissue invasion by the protozoa, particularly in the absence of inflammatory reaction, may be considered as *post mortem* migration in all animals studied.

These conclusions are based upon observations on material from cases of natural infection. The tissue was fixed at varying time intervals after death, and the lesions studied in serial section.

20. Food Reactions of Balantidium coli. (10 min.) E. C. Nelson, Johns Hopkins University.

Quantitative data have been secured showing a considerable difference in the ingestion of various organic and inorganic materials. Of the substances tested, starch and blood cells were found to be ingested with the greatest avidity. Inorganic substances were not ingested to any extent. Some substances however when treated with starch were ingested readily. A remarkable difference was also noted in the defecation of the substances ingested. Some data on the food requirements of *Balantidium coli* in culture have also been obtained.

21. I. The Endamoeba histolytica *and the* Balantidium coli. *II. The Life History of the* Diphyllobothrium latum. (Motion pictures.) R. B. H. Gradwohl, St. Louis.

22. Comparative Study of Diphyllobothrium cordiceps *and* D. latum. (10 min.) (Also by demonstration.) Mary Scott Skinker, Bureau of Animal Industry, Washington, D. C.

A comparative study of the tapeworm *Diphyllobothrium cordiceps* (Leidy, 1872) Meggitt, 1924 (for which the usual definitive hosts are the pelican and gull and the second intermediate hosts trout) and the broad fish tapeworm, *D. latum* (Linnaeus, 1758) Luehe, 1910, has been made. No characters are found which may be used as a basis for differentiation of the two species. Therefore, on the basis of morphology of the material available for study, *D. cordiceps* for the present must be considered a synonym of *D. latum.*

23. Diphyllobothrium cordatum (*Leuckart, 1863*) *in Bears of Yellowstone Park, Wyoming.* (15 min.) (Lantern.) (Also by demonstration.) John W. Scott, University of Wyoming.

Rush (Journal of Mammalogy, 1932) has reported *Diphyllobothrium latum* from bears in Yellowstone Park. In August, 1932, through the courtesy of the Park Service, the writer obtained at autopsy two tapeworms from one of the dangerous bears that had to be killed. These proved to be *D. cordatum* (Leukart, 1863). In addition there have been examined tapeworms collected by L. A. Woodbury from three other bears in the Park, and one entire specimen and the anterior stained portion of another kindly loaned by Rush from his collection. All these tapeworms belong to *D. cordatum.*

We have not been able to distinguish the ova from those of *D. latum.* The plerocercoids in Yellowstone trout are also indistinguishable from the plerocercoids of *D. latum* figured by Vergeer (1929). Some are longer than the measurements usually given for *D. latum.* One measured 18 centimeters, alive and extended. Proglottids were counted in six strobila, and the largest number found in a complete adult strobila was 410. Ward, Vergeer and others have pointed out the wide distribution of Diphyllobothrium plerocercoids in North American fishes. In view of the foregoing facts our present views in regard to the distribution of *D. latum* will probably have to be revised. Only one case of human infection with *D. cordatum* has been reported, a woman in northern Greenland

in 1860. Recovery of adult worms is at present the best test for the distribution of *D. latum*.

24. Complementary Note to my Observations on the Life History of Moniezia expansa. (10 min.) D. F. Sinitsin, Los Angeles.

The intestine of a sheep infested with *Moniezia expansa* as a rule contains a large number of empty egg-shells of the worm. Many of them are whole and possess a small pore encircled with a thick ring. This proves that the occupants, before they chanced to get into the intestine of the sheep, had already reached the end of their development somewhere outside. This proves also that the embryo, at the end of its development, in spite of being protected by the outer shell, cannot stand the digestive activity of its prospective host.

Some authors have inferred from my paper on the life history of *Moniezia expansa* (Journal of Parasitology, June, 1931) that the embryo develops while the egg is dry. This is an error. The embryo develops and the horns of its capsule twist only while the egg is moist, and only in such conditions by the 45th day of development, have some of the capsules turned 540 degrees. (Shown in my Fig. 3, although I failed to mention it in the text.)

25. Attempts to Grow Cestodes in vitro. (8 min.) Horace W. Stunkard, New York University.

Specimens of *Crepidobothrium lönnbergi* were removed from the intestine of Necturus and washed in sterile Ringer's Solution. They were then transferred to a sterile isotonic salt-dextrose solution, the salt content of which was adapted from Craig's medium for the cultivation of intestinal protozoa. The medium was modified by the addition of different amounts of Hottinger broth prepared by the digestion of veal, and a series of cultures were prepared with pH values varying from 6.5 to 7.8. The cultures which varied around pH 7.3 seemed most favorable. The worms were kept in petri dishes at room temperature and transferred to new media every 12 hours. In one experiment, young specimens were kept alive for 32 days. During this time they increased 3 to 4 times in length and the terminal portion of the strobila became definitely segmented, but the proglottids were abnormal and sterile. Addition to the media of salt extracts of the intestinal mucosa, pancreas, and liver of Necturus, sterilized by filtration, did not appreciably alter the rate of growth or time of survival. The exclusion of free oxygen by anaerobic culture methods did not affect the result. Fresh serum from Necturus was definitely toxic to the worms.

26. The Effect of Soil Types on Helminthic Parasites of a Lizard, Leiolopisma laterale. (15 min.) (Lantern.) (Charts.) Paul D. Harwood, Vanderbilt University.

A number of specimens of the common skink, *Leiolopisma laterale,* from four stations located on different types of soils were examined for parasitic helminths. Four species were found to be common parasites of the skink at one or more of these stations. At station I, on Acadia clay, 41 per cent of 88 lizards were infested with *Cylindrotaenia americana,* 24 per cent with *Brachycoelium daviesi,* 23 per cent with *Thubunaea leiolopismae,* but *Oswaldocruzia leidyi* was absent. At Station II, on poorly drained and very find Acadia sandy loam, 41 per cent of 22 lizards harbored Brachycoelium, 20 per cent Thubunaea, and 54 per cent Oswaldocruzia. Cylindrotaenia was not found. At Station III, on well drained and very fine Acadia sandy loam, 29 per cent of 21 lizards were infested with Brachycoelium. The other three species of parasites were not found. Of 15 lizards taken at Station IV, on a red, calcareous clay of the Miller series, 33 per cent harbored Cylindrotaenia, 7 per cent Brachycoelium, and 27 per cent Thubunaea. Oswaldocruzia was again absent.

It is probable that all of these parasites except Oswaldocruzia possess an indirect type of life cycle, and accordingly, the effects of varying soils may be due to the limitation of suitable intermediate hosts to certain soils. Oswaldocruzia probably possesses a direct life cycle, and here the action of the soils must be upon the free-living stages. Whether this action is chemical, physical or biological can not be determined with the data at hand.

27. The Sedimentation Method in the Diagnosis of Schistosomiasis mansoni. (10 min.) W. A. HOFFMAN and J. A. PONS, School of Tropical Medicine, San Juan, P. R.

The examination of 0.075 ml. of feces from the sediment of one gram samples is superior to the smear method for the detection of *Schistosoma mansoni* ova. The sedimentation method provides a more accurate picture of the incidence of schistosomiasis in endemic areas, and can be advantageously employed for the semi-quantitative estimation of the effect of treatment as determined by the number of ova.

28. The Life History of Troglotrema mustelae *n. sp.* (8 min.) (Lantern.) (Also by demonstration.) F. G. WALLACE, University of Minnesota.

The adult of a fluke closely related to *Troglotrema salmincola* has been found in the mink and reared experimentally in the dog, cat, fox, mink, rat, raccoon, ferret and skunk. Attempts to infest guinea pigs and ducks were unsuccessful. The parthenitae have been found in *Campeloma rufum.* The microcercous cercariae resemble *C. trigonura* (Cort, 1914). A posterior glandular organ, opening ventrally, produces a mucus which entangles the larvae and keeps them suspended in the water. Metacercariae have been collected and reared in a wide variety of fish but are found chiefly in Amieurus where they infest the bases of the fins and barbules. The metacercariae mature in the mammalian host in five days.

29. Amphibian Parasites of the Orders Strongyloidea, Dioctophymoidea and Trichinelloidea (Nematoda). (By Title.) A. C. WALTON, Knox College.

The order Strongyloidea has two families, Trichostrongylidae and Amidostomidae, with representatives as parasites of Amphibia. The sub-family, Trichostrongylinae, contains the genus, Oswaldocruzia, which has 13 species parasitic in Amphibia. In a forthcoming publication descriptions of these species, of which one is new, are given. Thirty-four species of Amphibia from every continent except Australia are parasitized. One species of the genus Amphibiophilus (family Amidostomidae) is recorded from an African frog. An immature form of Eustrongylides sp. has been recorded from a North American frog. This species, normally a fish parasite, is the only representative of the order Dioctophymoidea. Five species of the genus Capillaria (family Trichinellidae) from eight amphibian species are recorded from Europe and Asia. Synonymy of parasite names and of host names is brought into line with modern usage.

30. The Germ Cell Cycle in Trematodes. (By Title.) ARTHUR E. WOODHEAD, University of Michigan.

The Gasterostomata and Leucochloridium have branching mother-sporocysts. In the literature these have been considered to give rise to cercariae directly. However, in the gasterostomes the mother-sporocyst is hermaphroditic, and produces an hermaphroditic redia. Recently Leucochloridium has been found in quantity on the west shore of Lake Erie. The mother-sporocyst reveals a reproductive process very similar to that of the gasterostomes. It is hermaphroditic and produces an hermaphroditic redia.

31. The Lymph System of Zygocotyle lunatum, *with a Note on the Sub-family Zygocotylinae.* (By Title.) CHARLES H. WILLEY, New York University.

Through the kindness of Dr. M. C. Hall, Chief of the Zoological Division, Bureau of Animal Industry, several specimens of *Zygocotyle lunatum* were loaned to me for study. This material was collected from three host species, *Anas boschas, Anser anser,* and *Bos taurus.* Price (1928) has shown that *Zygocotyle lunatum* occurs in both birds and mammals. The lymph system in the material examined consists of a single pair of longitudinal vessels, dorsal and slightly medial to the intestinal caeca, with branches to various body organs. Bhalerao (1931) in a revision of the diagnosis of the sub-family Zygocotylinae to contain the new genus and species *Stunkardia dilymphosa* described the sub-family as containing parasites of only reptiles and birds and as having a lymph system consisting of a pair of dorsal and a pair of ventral canals. On the basis of the host relationships as demonstrated by Price, and on the basis of the morphology of the lymph system as here reported for Zygocotyle, the type genus, the diagnosis of the sub-family as modified by Bhalerao must be revised.

32. Cercaria sphaerula, *n. sp., Infesting Cyclops.* (By Title.) LYELL J. THOMAS, University of Illinois.

Cercaria sphaerula, n. sp., a larval trematode of the family Hemiuridae was observed by the writer and a student, Dean Johnson, while at the University of Michigan Biological Station, the summer of 1932. The cercariae, shed in numbers by the snail, *Helisoma trivolvis,* sink to the bottom of the aquaria. The modified tail resembles a minute sphere with a handle. This cystic tail completely envelopes the body proper and is approximately 450 μ in diameter. Another tube-like appendage with refringent granules near the distal end has a thick-walled bulb and spore at the tip. This tube, observed to be thrust in and out of the cyst, seemed to serve as a lure for the copepod, *Cyclops vulgaris,* which ingested the entire cyst. Free in the body cavity of the Cyclops the cercaria shows minute spines covering the anterior end to the base of the oral sucker. Oral sucker, about 18 μ in diameter, subterminal and ventral. Pharynx, 12 μ in diameter, muscular, follows immediately. Esophagus short. Intestinal crura, 50 μ long, extend laterally almost to the heavy-walled Y-shaped urinary bladder at the posterior end. Acetabulum, about 22 μ in diameter, approximately 72 μ from anterior end. Body proper, about 144 μ long by 40 μ at widest part.

33. Studies on the Development of Cercaria bessiae *Cort and Brooks, 1928.* (By Title.) WENDELL H. KRULL, U. S. Bureau of Animal Industry, Washington, D. C.

Cercaria bessiae Cort and Brooks, 1928, develops into *Neascus ambloplitis* Hughes, 1927. The cercariae were obtained from a snail, *Helisoma trivolvis* (Say), collected near Cushing, Oklahoma. Small fish, *Eupomotis gibbosus* (Linn.) were infected in the laboratory. The first metacercariae matured in one month in heavily infected fish, and in seven weeks pigmented cysts could be seen in the muscles of the living fish. The fish used in the experiment were taken from a small acid pond in which snails are not found; control fish were used in the experiment. The development of the metacercaria takes place in a roomy outer cyst, and when growth has been completed an inner, closely investing cyst is produced, after which the outer cyst becomes pigmented.

34. Studies on the Life History of Cotylophoron cotylophorum *(Fischoeder, 1901), Stiles and Goldberger, 1910.* (By Title.) WENDELL H. KRULL, U. S. Bureau of Animal Industry, Washington, D. C.

Snails, *Fossaria modicella* Say, collected near Salt Lake City, Utah, have ben experimentally infected with *Cotylophoron cotylophorum* (Fischoeder, 1901) Stiles and Goldberger, 1910. The eggs of *C. cotylophorum,* from which miracidia

were obtained, as well as adult flukes, were collected by Dr. M. C. Hall at Mayaguez, Puerto Rico. The snails produced cercariae in 32 days; control specimens were negative. Eleven infected snails shed a total of 1673 cercariae. Some of these snails shed cercariae for nearly 6 weeks, the cercariae escaping daily between 7:30 A. M. and 1 P. M. Cercariae usually encysted promptly on lettuce or on the sides of the aquarium. Encysted cercariae have been kept alive for 3 months and are still living. Encysted cercariae fed to trematode-free calves 3 months old, developed and produced eggs which were recovered from the feces in the fourth month after infection. Laboratory-raised snails, descendants of the snails collected in Utah, were infected but all died before reaching the stage of cercaria production.

The presence of *C. cotylophorum* in Puerto Rico not only constitutes a new locality record but is, apparently, the first record of this amphistome from the Western Hemisphere. Since the snail used in this experiment was taken in a territory from which *C. cotylophorum* has never been reported, it is possible that this fluke may extend its range and spread to some of the western states if the parasite is imported.

35. The Life History of the Human Intestinal Fluke, Euparyphium ilocanum *(Garrison, 1908).* (By Title.) MARCOS A. TUBANGUI, Bureau of Science, Manila, P. I.

Eggs of the intestinal fluke, *Euparyphium ilocanum* (Garrison, 1908) (=*Echinostoma ilocanum*), obtained from infested individuals, reached the miracidial stage after 6 to 15 days in tap water with room temperature 26° to 31° C. Hatching took place 3 to 5 days after formation of miracidia. By exposing different species of laboratory-raised, fresh-water snails to free-swimming miracidia, it was determined that *Planorbis compressus* Hutton and *P. umbilicalis* Benson are capable of playing the rôle of first intermediate hosts for the parasite. In these snails miracidia developed into first and second generation echinostome rediae and later into cercariae armed with fifty-one collar spines each. The cercariae soon leave their first intermediate hosts and, after swimming for a certain length of time encyst and are transformed into metacercariae. Cysts were found attached to the walls of the mantle cavity of the first intermediate hosts and of other kinds of snails, such as *Bulinus hungerfordianus* (Nevill) and *Lymnaea peregra* (Müller), that were kept in a common aquarium with the Planorbis species. It remains to be determined whether encystment will take place in any species of fresh-water snail, in water or on aquatic vegetation. Cysts, fed to clean laboratory white rats, developed into adult *Euparyphium ilocanum* after 11 to 16 days. From the results it is inferred that human infestations with the parasite are due to consumption of raw or insufficiently cooked snails harboring encysted metacercariae. Such a habit prevails in many localities in northwestern Luzon, Philippine Islands, where the parasite is common.

36. Some New Trematodes of the Family Heterophyidae. (By Title.) E. W. PRICE, U. S. Bureau of Animal Industry, Washington, D. C.

Recently a portion of the intestine of a Butorides sp. was sent to the Bureau of Animal Industry by H. L. Van Volkenberg, Mayaguez, Puerto Rico. Attached to the mucosa were three species of heterophyids, one of which appears to be *Phagicola diminuta* (Stunkard and Haviland); the others are regarded as new.

Ascocotyle megalocephala, n. sp. Body shaped like a tall beaker, 340 to 510 μ long by 120 to 220 μ wide (width of anterior end equal to maximum body width); oral coronet with 72 spines, 36 in each row; uterus pretesticular, extending anteriorly as far as pharynx; vitellaria lateral, extending from level of pharynx to level of center of acetabulum. Location: large intestine. Differs

from other species of Ascocotyle in body shape, number of spines in oral coronet, and in position of vitellaria.

Ascocotyle puertoricensis, n. sp. Body piriform, 260 to 460 μ long by 170 to 200 μ wide; oral coronet with 32 spines, 16 in each row; vitellaria lateral, extending to posterior end of body. Location: large intestine. Differs from *A. coleostoma* (Looss) in extent of vitellaria, which in *A. coleostoma* extend only to level of anterior margin of testes, and from *A. filippei* Travassos in number of spines in oral coronet (36 in *filippei* and 32 in *puertoricensis* and *coleostoma*).

In addition to the descriptions of new species, on publication the author will give a review of the subfamily Centrocestinae, together with redescription of some of the old species and new host records for others.

37. The Development of Strongyloides in the Experimental Host. (12 min.) (Lantern.) Ernest Carroll Faust, Tulane University.

The stages of infection following inoculation of a susceptible animal with strongyloides may be appropriately divided into (1) the prepatent or incubation period, (2) the patent period or that during which the parasitic females are laying eggs, and (3) the post-patent period, in which mature female worms are still present in the host's tissues but have passed the stage of egg production. Differential development of the invading filariform larvae through the post-filariform stage into the parasitic males and females is described. The discovery of the parasitic males and their relationship to production of viable eggs is presented. The adaptability of the worm to partial and complete development in host's tissues other than intestinal mucosa is also considered.

38. The Basic Plan of the Nervous System of Nematodes. (10 min.) (Lantern.) B. G. Chitwood, U. S. Bureau of Animal Industry, Washington, D. C.

The central nervous system and cephalic nerves of nematodes appear to conform to a common plan based on cell constancy. Study of the nerve ring and associated ganglia in nematodes of various groups shows that few changes occur. Six nerves supply the cephalic sensory organs of which there are two types, namely, papillae and amphids. Neurones connected with papillae pass directly into the nerve ring, while those connected with amphids pass first through the lateroventral commissure to the subventral nerve trunks and thence back to the nerve ring.

The number and arrangement of the cephalic sensory organs of nematodes fall within a single plan from which any of the conformations may be derived. Amphids are apparently invariably present, usually lateral, either on the lips or posterior to the labial region. The maximum number of papillae (16) occurs in many nematodes, representatives of widely separated groups. In the internal circle there are 6, for which the terms internodorsal, internolateral, and internoventral are proposed, and in the external circle are 10, the dorsodorsal, laterodorsal, ventrolateral, lateroventral, and ventroventral papillae. The amphids often lie in a position dorsal to the ventrolateral papillae; however, their structure and nervous connections indicate that they are of entirely separate origin. Hypothetically, there should be a pair of dorsolateral papillae to complete the symmetry but no form is known in which this occurs. Groups of papillae may become reduced or rudimentary and fusions also occur, but the nervous connections of the papillae are unaltered.

39. The Value of Head Characters in Nematode Taxonomy and Relationship. (12 min.) (Lantern.) (Also by demonstration.) B. G. Chitwood and Everett E. Wehr, U. S. Bureau of Animal Industry, Washington, D. C.

A critical study of the head characters of many genera and species of the superfamily Spiruroidea has been made, with emphasis placed, to a large degree,

on the number and arrangement of the cephalic papillae, their character and position on the head, and the homology and character of the labial organs. The constancy of the number, position and character of the head papillae, and of the type and number of lips within limited groups of nematodes of the superfamily Spiruroidea make these structures valuable in nematode classification. On the basis of these and other body structures, the investigators submit the following system of classification of the superfamily Spiruroidea. THELAZIIDAE: Thelaziinae, Thelazia; Spirocercinae, Spirocerca, Oxyspirura, Cylicospirura, with Rhabdochona as doubtful; Rictulariinae, Rictularia, with Rictularoides, Echinonema, and Pneunonema as doubtful; Gongylonemінае, Gongylonema; Arduennінае, Arduenna, Physocephalus, Streptopharagus, Simondsia, Paraleiurus, Spirocercella. ACUARIIDAE: Acuariinae, Acuaria, Chevreuxia, Cheilospirura, Cosmocephalus, Synhimantus, Dispharynx, Echinuria, Aviculariella; Seuratiinae (n. subf., type Seuratia), Seuratia, Streptocara, Yseria. SPIRURIDAE: Spirurinae, Spirura, Cystidicola, Protospirura, with Seuratum as doubtful, and with Oslerus, Spinitectus and Filaroides as appendices; Hedrurinae, Hedruris; Habroneminae (n. subf., type Habronema), Habronema, Seurocyrnea, Parabronema; Tetramerinae, Tetrameres, Microtetrameres. CAMALLANIDAE: Camallanides, Paracammallanus, Camallanus, Procamallanus. CUCULLANIDAE: Cucullanus, Bulbodacnitis, Serradacnitis, Dacnitoides. PHYSALOPTERIDAE: Physaloptera, Chlamydonema, Thubunea, with Proleptus as doubtful. ANCYRACANTHIDAE: Ancyracanthus, Viguiera, Torquatella, Serticeps, Ancyracanthopsis, Histiocephalus, Schistorophus, Sciadiocara. GNATHOSTOMIDAE: Gnathostominae, Gnathostoma, Tanqua, Echinocephalus; Spiroxinae, Spiroxys, Hartertia.

40. On a Nematode Parasite in the Brittle Star, Ophiocten amitinum *Lyman.* (15 min.) (Lantern.) Henry B. Ward, University of Illinois.

In a collection from the South African Museum at Capetown, Professor H. L. Clark found a brittle star (*Ophiocten amitinum* Lyman) parasitized by a nematode. The material which was placed in my hands for study had been dredged from a depth of 100 fathoms near Port Alfred. The worms were coiled in the disc of the brittle star and are faintly visible through the body wall. When the specimen was preserved both ends of the worm were forced apart and now project beyond the torn body wall. Four host specimens were received. From one to five worms are found in each host and each worm lies in 1½ coils more or less. Worms are about 16 to 18 mm. long by 0.13 to 0.2 mm. wide, of nearly uniform diameter throughout and tapering a little near the ends which are slightly truncated or bluntly rounded. The form is sexually immature. Its structure is described in the paper. No records of a similar form have been found in the literature. The name of *Thalassonema ophioctinis* is given to it.

41. Ciliates from Sea Urchins. (12 min.) (Lantern.) Philip B. A. Powers, University of Pennsylvania.

Seven species of ciliates, five of which are new, were found infesting the alimentary tract of *Strongylocentrotus drobachiensis,* the sea urchin common to the north-eastern coast of North America. *Entodiscus borealis* Hentschel is redescribed as the result of a study of sectioned material whereby the structure of the cytostome could be ascertained. This species possesses a well defined neuromotor apparatus as well as a supporting rod about the right border of the cytostome. *Entodiscus indomitus* Madsen is also described more fully in the light of observations made on the sectioned material. A new species of Cryptochilum is described, with its relationship to the genus Entodiscus. The morphology is considered of the remaining four species, an Anophrys, a Plagiopyla, a Trichodina, and an Euplotes, together with their relationship to other co-genera

reported as infesting sea urchins. By the use of OsO_4 techniques, a system of vesicles has been demonstrated in the anterior region of four of these species. It is suggested that these vesicles may be of secretory nature.

42. Studies on the Gregarines of the Oligochaeta. (15 min.) (Lantern.) (Also by demonstration.) RAPHAEL A. TROISI, University of Pennsylvania.

Descriptions of several new species of gregarines with their life histories are presented. These new species from the seminal vesicles of their hosts are distributed in the genera Monocystis, Rhynchocystis, Apolocystis, and Nematocystis.

The phenomenon of cytosomal division unaccompanied by nuclear division is described for the first time. After this unequal division of the cytosome, the nucleated portion undergoes drastic structural changes and finally becomes the pre-cystic form; the enucleate portion disintegrates. Those organisms which are large and undergo cytosomal cleavage before encystment produce clear cysts with no residual masses. Other gregarines not casting off any portion of the body before encystment usually show large residual masses of cytoplasm within the cysts after the completion of sporulation. It is also found that in many cases the hair-like processes attached to the surface of some gregarines are extensions of the cuticle and not the remains of spermatozoa. This is demonstrated by the fact that certain species possessing cuticular extensions are totally extra-cellular, never invading sperm-mother cells.

43. Notes on Myxosporidia. (10 min.) R. R. KUDO, University of Illinois.

During the past several years fishes of Illinois have been examined with especial refrence to histozoic myxosporidian parasites. These organisms are in general common parasites in the fishes belonging to three families: Catostomidae, Cyprinidae and Siluridae. Nineteen new species belonging to four genera and four known species of this group of protozoa have been so far observed. While the majority of Myxosporidia show a specificity of host species, there are some which occur in many species of fish. *Myxobolus notatus* Mavor, which has hitherto been known to confine itself to the blunt-nosed minnow in the American waters, was found to attack also the bullhead minnow, common shiner and straw-colored minnow, all collected from the Rock River, Illinois. *Henneguya exilis* Kudo on the other hand was found, as was originally described, only in the channel cats which were obtained from the various tributaries of the Mississippi River and in no other members of the Siluridae so far examined. In a species of Myxobolus, the trophozoites which were lodged in a large number in the host's integument, were much like those of polysporous coelozoic Myxosporidia.

44. Trichomonas muris, *Parasitic in Oxyurids of the White Mouse.* (15 min.) (Lantern.) HANS THEILER and SEYMOUR M. FARBER, Harvard University.

In addition to a variety of other parasites, the laboratory stock of white mice was found to harbor *Trichomonas muris* and the oxyurids *Aspicularis tetraptera* and *Syphacia obvelata.* Most of the mice infected with the flagellates were also infected with the nematodes. Varying numbers of actively motile trichomonads were found in the chyle-intestine of a relatively large proportion of the worms. At first it appeared that the flagellates were restricted to *A. tetraptera,* but later *S. obvelata* also was found to be infected, though more frequently in the former than in the latter. The numbers of the flagellates in the oxyurids varied from single or few individuals to a dense mass of organisms which prevented movement of the distended chyle-intestine. The morphology of the organisms and the measurements obtained indicate that the flagellates in the helminths and those free in the intestinal contents of the mice are both *T. muris.* No injury or invasion of the helminthic organs or tissues was found. The flagellates were always found free in the lumen of the chyle-intestine and never intracellularly. There was evidence of multiplication of the protozoa but none of transmission through the egg.

45. Seasonal Incidence and Concentrations of Sand Fly Larvae in Salt Marshes (Culicoides). (15 min.) (Lantern.) J. B. Hull, W. E. Dove and D. G. Hall, U. S. Bureau of Entomology, Savannah, Ga.

During the autumn months at Charleston, S. C., concentrations of sand fly larvae occur in wet soil of shady areas of salt marshes. Later, when the marshes are inundated by tides and rainfall the larvae are dispersed to the open marshes. Following these dispersions, new concentrations of larvae occur in depressions, near barriers and in the wet soil of ditches. The studies suggest that ditches designed for elimination of breeding places of mosquitoes in low marsh areas may either despatch sand fly larvae to deep water or concentrate them in the wet soil of ditches. The ditch soil is favorable for development of the larvae, but in such places the larvae are accessible to treatments for their destruction.

46. Production of Sterile Maggots for Surgical Use. II. Disinfection with Sodium Hydroxide Followed by Formalin. (15 min.) (Lantern.) (Also by demonstration.) G. F. White, U. S. Bureau of Entomology, Washington, D. C.

If the maximum good to the greatest number of patients is to be realized from the remarkable post-operative maggot treatment for osteomyelitis and other infected wounds, introduced by the late Dr. William S. Baer, the maggots must be sterile, must be available in ample numbers throughout the year, and must be obtainable at low cost. In a method for their production everything within reason must be included to accomplish these objectives. Eggs used in rearing clinical maggots are secured from flies obtained from larvae hatched from sterilized eggs and grown on autoclaved food, and afterwards maintained relatively free from disease-producing organisms. The aim in disinfection is to destroy spores as well as vegetative forms of all pathogenic agents present without destroying the eggs. The eggs are readily separated in a 1 per cent aqueous solution of sodium hydroxide, are immersed for three hours in a 4 per cent solution of the hydroxide at room temperature, are washed, and are then immersed for 30 minutes in 5 per cent formalin. Potassium hydroxide may be substituted for the sodium compound but is less desirable. Eggs disinfected too soon after laying or too near hatching result in relatively high mortality. Eggs collected over a period of two or three hours are therefore allowed to remain two or three hours at room temperature or overnight at approximately 10° C. before being sterilized. Maggots hatching from disinfected eggs are fed on autoclaved lung or other suitable meat. Microscopic and cultural tests for sterility are made before the maggots are released for implantation.

47. A New Filarid from the Abdominal Cavity of a Bat. (By Title.) Allen McIntosh, U. S. Bureau of Animal Industry, Washington, D. C.

The nematodes briefly described here were collected from bats, *Nycticeius humeralis,* in the District of Columbia.

Litomosa americana n. sp. *Male:* 12 mm. long by 110 μ wide, attenuated posteriorly. Head bluntly rounded; buccal cavity 20 μ in diameter, conical, with apex directed posteriorly. Esophagus cylindrical, 300 to 350 μ long by 40 to 50 μ wide; nerve ring in second fourth of esophagus. Spicules unequal: left 260 μ long by 8 μ wide, ending distally in a long lash; right 90 μ long by 7 μ wide, terminating in a short bipartite process. Posterior part of body with two to three spiral coils; anus 95 μ from tip of tail; tail tapering gradually, rounded at tip. *Female:* head, buccal cavity, and tail similar to those of male. Vulva near level of nerve ring, 150 μ from anterior extremity; ovejector long. Sheathed microfilariae in blood.

This species may be separated from *Litomosa filaria* (Beneden, 1873) Yorke and Maplestone, 1926, the type and only other species in the genus, as follows: Buccal cavity with apex directed posteriorly instead of anteriorly; vulva near level of nerve ring instead of at level of base of esophagus; female tail rounded at its extremity and without the four spine-like processes found in *Litomosa filaria.*

48. The Life History of a Trichostrongyle, Longistriata sp., Parasitic in Mice. (By Title.) BENJAMIN SCHWARTZ and JOSEPH E. ALICATA, U. S. Bureau of Animal Industry, Washington, D. C.

Infective larvae were obtained by culturing the feces of wild mice, *Mus musculus,* received from Jeanerette, La. The larvae penetrate the skin of white mice readily. Some were recovered from the subcutaneous tissue near the adjacent muscles four hours after they had been placed on the skin. The larvae appear in the stomach as early as three hours after being placed on the skin. They migrate from the stomach to the small intestine, where they develop to fertile maturity, eggs appearing in the feces on the seventh day after percutaneous infection. The larvae do not appear to migrate to the stomach by way of the blood stream and lungs, since in a large series of tests with white mice killed at various intervals following percutaneous infection none were recovered from any thoracic or abdominal viscera or from the blood. Presumably, the larvae get into the stomach by penetrating its wall from without. When infective larvae were injected into the abdominal cavity, some were recovered from the peritoneal fluid, liver and spleen two and a half hours later, whereas in normal percutaneous infections they were not demonstrable in these locations.

Following a single infection, the period of egg production lasts for about a week. A superinfection results either in the reappearance of eggs beginning about the seventh day, or following a delay of many days, or eggs fail to appear altogether.

49. A Review of the Taxonomy in the Genus Onchocerca Diesing (Filariidae). (By Title.) J. H. SANDGROUND, Harvard University.

The question of the relationship between *Onchocerca volvulus,* associated with nodules predominantly on extremities and torso of man in Africa, and *O. caecutiens,* producing nodules on the head in Guatemala highlands, is still unsettled. Provided with an unprecedented abundance of material of the latter species, a morphological study was undertaken and comparison instituted with *O. volvulus* and bovine species from West Africa, Egypt, Madagascar, Australia and the equine *O. cervicalis.* The validity of all specific characters proposed in the genus was examined and other characters assiduously sought. The intraspecific variation of all such characters has been found so great as usually to nullify the differential criteria of many species. On morphological grounds it is contended that no distinction can be drawn between *O. volvulus, O. caecutiens, O. gibsoni* and several presumptive bovine species. An inconspicuous dilation in the cervical region of *O. gutturosa* is, however, apparently constant and permits differentiation from the aforementioned species. The larger size of *O. cervicalis* is apparently its only distinguishing character but this species is probably identical with *O. reticulata.*

In the absence of information concerning the life history of the adolescent worms in the mammalian host, the presence or absence of encapsulating nodules and their location cannot, in my opinion, be validly invoked to distinguish species. The bionomics of the insect vector may determine these considerations. On the basis of material received from Australia, it appears that *Filaria lienalis* Stiles, from the gastrolienic ligament of cattle, has been erroneously attributed to the genus Onchocerca.

50. The Anatomy of Troglodytella abrassarti. (By Title.) W. W. SWEZEY, Johns Hopkins University.

The ophyoscolecid ciliate, *Troglodytella abrassarti,* has been studied in the following types of preparations: (1) living, (2) individuals mounted and stained *in toto,* and (3) variously stained sections of individuals and masses of organisms. The anatomy of the following structures and organelles has been worked out: The cuticle and ectoplasm including the very distinctive skeletal apparatus, the inner boundary layer, endoplasm, macronucleus, micronucleus, contractile vacuoles,

peristome, oesophagus, anal region, and ciliature. Nothing analogous to a motorium or to the neuromotor apparatus described by Sharp (1914) in Diplodinium was found. The skeletal structure is similar to that described by Reichenow (1920), minor differences being found in the number and arrangement of the pieces. No contractile fibrillae or folds in the cuticle were found which would explain the shortening and lengthening of the "tail" or posterior end in response to temperature changes. The most plausible explanation, at present, for this phenomenon seems to be that one or a number of internal changes, such as imbibition of fluid, ingestion of food or other solid particles, alterations in the salt concentration, etc., resulting from variations in temperature, cause an increase in the body volume. Inasmuch as the body is completely enclosed within a rigid structure except in the posterior region, expansion of the elastic caudal cuticle takes place to accommodate the change in body volume. Very few points at distinct variance with the anatomical structure of other Ophyoscolecidae were noted and most of these were peculiarities due to the genus itself.

51. A Description of the Larva of Anopheles atropos *Dyar and Knab, with Biological Notes on the Species.* (By Title.) E. Harold Hinman, Tulane University.

A detailed description of the mature larva of this species is given for the first time in a forthcoming publication. Information on the distribution, breeding grounds, life cycle, feeding habits of the adults, etc., is included. While Mayne and Griffitts have shown the species to be susceptible to experimental infection it is doubtful if *A. atropos* plays an important rôle in the transmission of malaria owing to its limited distribution and the relatively low incidence of malaria throughout this region. Dissection of adult females captured in the wild have failed to reveal infection.

52. Comparative Study of Acariasis of the White Rat (Rattus norvegicus *form albinus*). (By Title.) Louis V. Skidmore, University of Nebraska.

In August, 1929, an outbreak of acariasis occurred in a colony of white rats used in a nutrition experiment. The mites found on these rats as well as those collected locally from the brown rat (*Rattus norvegicus*) belonged to Myobia sp. but are not like *Myobia musculi* found on the common house mouse (*Mus musculus musculus*) in this vicinity or described by Edouard Clarapède (1868) in his "Studien an Acariden." Mégnin (1878; 1892) describes the *Myobia musculi* (Clarapède) found on rats, his description being in accordance with my findings. I propose the name *Myobia ratti* to distinguish the Myobia sp. found on rats from *Myobia musculi* which is found on the common house mouse.

Some of the white rats from the infested colony were kept under observation for more than a year, at the end of which time they were still infested with Myobia. Infestation of the colony of rats used in the nutrition experiment very likely occurred from wood shavings stored in a cattle barn, which were used for bedding the rat cages. In later experiments the wood shavings were dry heated to 110° C. for 24 to 48 hours before being used for bedding. No further outbreaks of acariasis occurred.

53. Is Parasitology a Science? Maurice C. Hall, U. S. Bureau of Animal Industry, Washington, D. C. (This paper is the presidential address.)

Comments made by some scientists to the effect that parasitology is not a science may be paralleled by those of other scientists to the effect that taxonomy, psychology, economics, etc., are not sciences. Such remarks are in line with the observation not infrequently heard that this or that scientific finding is unimportant. All these comments are challenged as unscientific in fact and in the mental attitude represented.

The truly scientific mental attitude is dispassionate, impersonal and devoid of emotional bias. As such it is an ideal unattainable by human beings, and we have

nothing better than human beings from which to make scientists. We take our emotions into our laboratories, and we leave our scientific mode of thought in our laboratory when we go out and deal with our fellow men and with politics, sociology and economics. Outside of our laboratories we live in a world that believes in witchcraft, fairies and magic, and the scientist should lead, as he does not, in combating childish beliefs and infantile desires. American civilization pays lip homage to science, but has little concept or appreciation of science and does not understand its methods or its objectives. It still pays its tributes of appreciation and admiration, especially officially, to its heroes of war, politics and finance, but has rather little regard for its men of art, music, literature and science. Future generations of Americans and scientists may do better.

54. The Intestinal Protozoa of the Larvae of the Crane Fly, Tipula abdominalis. (Demonstration.) QUENTIN M. GEIMAN, University of Pennsylvania.

One hundred larvae of the dipteran, *Tipula abdominalis,* were collected from five streams near Philadelphia, one stream in New Jersey and one in Florida. The living protozoa in the contents of the hind gut were studied and smears made. To give a comprehensive picture of the respective morphology of each protozoan present, a number of different fixatives and stains were used in making the permanent preparations. A survey of the protozoa in each of the prepared series of slides has been made, revealing ten distinct species of flagellates and at least two species of amoebae. The following seven species of flagellates and the two speces of amoebae have been described previously: (flagellatae) *Rhizomastix gracilis, Retortomonas (Embadomonas) agilis, Retortomonas (Embadomonas) alexeiffi, Polymastix melolonthae, Monocercomonas melolonthae, Monocercomonas orthopterorum, Eutrichomastix trichopterae* var. *tipulae;* (amoebae) *Endamoeba minchini, Vahlkampfia* sp.

Polymastix wenrichi, n. sp., length 12–35 μ x width 8–22 μ x thickness approximately 3–5 μ, a four-flagellated protozoan, leaf-like in form, and body covered with fine longitudinal striations, was found in 12 per cent of the larvae. *Hexamastix batrachorum* var. *tipulae,* length 8–20 μ x width 4–12 μ, similar to *Hexamastix batrachorum* found in salamanders and frog tadpoles, but with a more extensively developed axostyle, was found in 53 per cent of the larvae. *Hexamitus lateralis,* n. nom., (= *Hexamitus intestinalis* Mackinnon), length 5–8 μ x width 2–4 μ, a typical hexamitid with the anterior elongate nuclei in a plane at right angles to the two widely separated lateral axostyles, was found in 46 per cent of the larvae.

55. Culture of Certain Protozoa, Bacteria-free. (Demonstration.) R. W. GLASER, Rockefeller Institute for Medical Research, Princeton, N. J.

Demonstration of certain protozoa including *Paramecium caudatum* and *P. multinucleata, Trichoda pura, Euglena proxima, Chilomonas paramecium,* and *Parypolytoma satura* growing in pure culture, bacteria-free.

56. Culture of a Parasitic Nematode. (Demonstration.) R. W. GLASER, Rockefeller Institute for Medical Research, Princeton, N. J.

Demonstration of *Neoaplectana glaseri,* parasite of the Japanese beetle, growing on special yeast medium.

57. Two New Cystocercous Cercariae from Alabama. (Demonstration.) SEPTIMA SMITH, University of Alabama.

Goniobases sp. collected in Alabama produced two new cystocercous cercariae. For one of these the name *Cercaria melanophora* is proposed; for the other the name *Cercaria hodgesiana.*

Cercaria melanophora is approximately 4.2 mm. in length by 1.4 mm. maximum bladder width. It is of striking appearance, with a deep yellow-brown distome which averages 1.6 mm. in length by 0.98 mm. in width and which half fills the ovoid enveloping trunk. The latter is diffuse-brown and is studded with numerous

spinose mammillations. The tail stem terminates in two anchor flaps, 1.12 mm. in length by 1.03 mm. in width, which are conspicuously pigmented in irregular brownish patches.

Cercaria hodgesiana has an approximate length of 3.8 mm., the globular bladder being about 1.5 mm. in diameter. It is clear and colorless with a pale yellow distome which averages 1.3 mm. in length by 0.86 mm. in width, and which fills less than half of the chamber. The latter is smooth in contour save for a protrusible terminal papilla at the point of invagination of the distome, and a few small irregularly disposed papillae which surround the same. The anchor flaps are 0.8 mm. in length by 0.7 mm. in width.

In internal organization the two distomes exhibit some morphological similarities and, in accordance with the known condition in certain other members of this group, possess mature and functioning reproductive organs.

58. A Species of Cephalogonimous from the Domestic Duck. (Demonstration.) CLIFFORD H. ALVEY, New York University.

Two specimens were obtained from the esophagus of a duck received from Missouri and kept for several weeks in the laboratory. One worm, mounted *in toto*, measures 1.4 mm. in length, 0.5 mm. in width, is much flattened dorso-ventrally, attenuated anteriorly, broadened posteriorly. Oral sucker terminal, spherical, diameter 0.17 mm.; followed by pharynx; acetabulum 0.19 mm. located 0.5 mm. from anterior end. Esophagus absent, digestive tract Y-shaped. Excretory pore terminal, opening from a rounded chamber, 0.084 mm. in diameter. Testes elongated transversely, near middle of body. Posterior testis mediad in position, anterior testis at the left of the median plane. Seminal receptacle between the anterior testis and acetabulum. Cirrus sac large, beginning dorsad at the level of the acetabulum on the right side and curving around the acetabulum to run obliquely between it and the pharynx. After crossing the left caecum it diminishes in size to open dorsad at the level of the oral sucker. Prostate gland occupies one-half the cirrus sac. Ovary spherical, located on right side in close contact with acetabulum. Uterus coiled, filled with eggs, occupies the entire region behind posterior testis. Eggs elliptical, 0.046 mm. long, 0.019 mm. wide. Vitelline follicles lateral to caeca, occupy the middle half of the body. The worm has been tentatively identified as *Cephalogonimous vesicaudus* Nickerson from the turtle.

59. Clinostomum attenuatum *from the Great Blue Heron.* (Demonstration.) CLIFFORD H. ALVEY and HORACE W. STUNKARD, New York University.

Worms collected by Professor R. Bennitt, of the University of Missouri, from the great blue heron, *Ardea herodias*, were referred to this laboratory for identification. A typical specimen measures 6.75 mm. in length, 2 mm. in width; post-acetabular region nearly uniform in width. Oral sucker terminal, 0.35 mm. by 0.38 mm., situated on a large oral cone. Acetabulum 0.81 mm. by 0.89 mm., located 0.76 mm. behind the oral sucker. Short esophagus present, digestive tract triclad, caeca extending almost to posterior extremity of worm. Excretory pore terminal. Testes lobed, pyramidal in shape, with their bases facing, one behind the other in the median line. Anterior testis located behind middle of post-actetabular region. Posterior testis located 1.2 mm. from posterior end. Ovary spherical, located between the testes on the right side of the median plane. Uterus crosses transversely from the ovary and runs anteriad on the left side of the worm, becoming greatly coiled in front of anterior testis to occupy the entire region between the testis and the acetabulum. Eggs elliptical, 0.099 mm. by 0.069 mm. The metacercarial stage of *Clinostomum attenuatum* was described by Cort (1913) from the frog. He concluded that worms from the bittern, *Botaurus lentiginosus*, described by Wright (1879) as *Clinostomum marginatum* actually are adults of *Clinostomum attenuatum*.

60. Ticks in Relation to Certain Diseases of Man and Animals. (12 min.) (Lantern.) F. C. BISHOPP, U. S. Bureau of Entomology, Washington, D. C.

This paper is a discussion of the life histories, habits and distribution of ticks which are known or suspected to be vectors of such diseases as Rocky Mountain spotted fever, tularemia, relapsing fever, anaplasmosis, and the newly described moose disease, and the bearing these studies have on the epidemiology of these diseases.

61. Effects of Quick Freezing upon Infective Larvae of Trichinella spiralis. (12 min.) (Lantern.) DONALD L. AUGUSTINE, Harvard University.

Pork loin roasts, in which trichinous meat had been inserted, were placed in "plate freezers" and their temperatures rapidly lowered. A temperature of −34.6° C. (the lowest) was obtained in six hours. Correspondingly less time was required to reach higher freezing levels. Temperatures were recorded by thermocouples inserted and tied securely in the trichinous meat. Heavy infections were encountered in all animals fed meat exposed to a temperature of −21° C. and slight infections were noted in all animals fed meat exposed to a temperature of −27.6° C. Slight infections were noted in about half the mice fed trichinous meat subjected to a temperature of −30.9° C. No infection resulted from the feeding of trichinous material lowered in temperature to −33.7° C., although about twelve per cent of the larvae appeared normal upon microscopical examination and reacted to heat. Microscopically, all larvae exposed to a temperature of −34.6° C. appeared to be destroyed and no infection resulted from the feeding of such material.

The study also includes observations on infective trichinella larvae after rapid freezing and storage for varying periods of time at several temperatures. It appears that "quick freezing" has certain advantages over the present method employed to render safe pork products which are customarily eaten raw, *viz.*, a storage period of at least twenty days at a temperature of not higher than −15° C. (+5° F.).

62. The Occurrence of Microfilaria ozzardi *in Panama.* (12 min.) (Lantern.) O. R. MCCOY, University of Rochester.

Microfilaria ozzardi (=*M. demarquayi*) was found in the blood of 44.5 per cent of 119 Indians examined in the Tuira River basin, Darien Province, Panama. The infection rate in native villages in the same region varied from 2 per cent to 57 per cent and averaged 9.9 per cent in the 244 natives examined. A few cases of infection with *M. ozzardi* were found in the Chagres River valley, Panama, but all of these were recent arrivals from the Atrato River valley, Colombia. No evidence was found that *M. ozzardi* is pathogenic or in any way a significant problem of public health importance. Southeastern Panama is an endemic center of infection with *M. ozzardi* heretofore unknown in the geographical distribution of the parasite.

63. Results of a Protozoological Survey of 401 College Freshmen. (15 min.) (Lantern.) D. H. WENRICH, R. M. STABLER and J. H. ARNETT, University of Pennsylvania.

In the fall of 1932, in connection with the regular medical examination of the entering class of a collegiate institution in Philadelphia, 401 of the freshmen were examined for intestinal protozoa. Only one stool per person was secured and no laxatives were given. The fresh material was examined in saline and in iodine, and stained slides were made from all cases and subsequently studied. Examination of fresh material alone revealed 153 findings of protozoa, stained slides alone, 167, and the two combined, 176. Incidences were: Blastocystis, 61.0 per cent; some protozoa, 33.1 per cent; *Endamoeba coli*, 13.2 per cent; *Endolimax nana*, 11.9 per cent; *Giardia lamblia*, 8.7 per cent; *Endamoeba histolytica* (including *E. hartmanni*), 4.4 per cent; *Dientamoeba fragilis*, 3.4 per cent; *Iodamoeba bütschlii*, 1.2 per cent and *Chilomastix mesnili*, 0.74 per cent.

As was to be expected, most of the protozoa were in the encysted state, Dientamoeba being an exception; and an incidence of this amoeba of 3.4 per cent indicates that it is not so rare as is commonly supposed. The average age of these students was 19 years and most of them came from homes in Pennsylvania or New Jersey. Few had traveled extensively. Of the 18 carriers of *Endamoeba histolytica* four had been as far south as Virginia and two had been abroad, one to Ireland and the other to Italy. There was little correlation between reported past and present symptoms, and the presence of any one of the protozoa.

64. Comparative Studies of Intestinal Protozoa in Different Species of Monkeys. (15 min.) (Lantern.) ROBERT HEGNER, Johns Hopkins University.

Surveys were made of intestinal protozoa in rhesus monkeys and chimpanzees in captivity and in *Macacus philippinensis,* the red-spider monkey, white-faced money and titi monkey in a wild state. It was found that examinations of 4 stools from each monkey revealed most of the species, although 10 or more stools are necessary for complete returns; and that any given species appears in almost every stool. The incidence of different species of protozoa in different species of monkeys differs significantly, indicating different degrees of susceptibility and resistance. These differences can be correlated with the anatomy and food habits of the host. For example, in the red-spider monkey with canine teeth poorly developed and a very large cecum indicative of a vegetarian diet, practically every specimen was parasitized by Balantidium, Trichomonas and an ameba. The titi monkey has fairly well developed canines and a medium-sized cecum; it was found to be inhabited by Trichomonas only. The white-faced monkey has large canines and a very small cecum and, in the wild state, was free from intestinal protozoa. These studies of wild monkeys confirm laboratory experiments on other animals which have demonstrated that certain intestinal protozoa thrive when the host is living on carbohydrates but disappear when the host is fed on animal protein.

65. The Behavior of the Avian Malarias in the Common Fowl, an Abnormal Host. (15 min.) (Lantern.) REGINALD D. MANWELL, Syracuse University.

Avian malarial infection has been reported from many bird species, and is said by Wenyon (1926) to occur in common fowl. Because the canary is too small for types of experimentation requiring much blood, the present study was undertaken. Five malarial species were used: *Plasmodium cathemerium, praecox, elongatum, rouxi,* and *circumflexum.* Chickens used were Plymouth Rocks and Rhode Island Reds, aged four days to three weeks when inoculated (majority under two weeks). Inoculation was either intravenous or intramuscular, with massive parasite doses, at least 100 times as large as required to infect canaries, even after considering difference in weight between chickens and canaries. Intramuscularly inoculated chicks never showed parasites in their blood, and intravenously inoculated birds gave similar results in most cases. Even when parasites could be microscopically demonstrated numbers were always very small, and in no case was it possible to secure positive results with *Plasmodium elongatum* or *P. rouxi.* Inoculation of large doses of blood (up to 450 cmm.) from intravenously inoculated chicks into clean canaries however showed that the chick blood remains infective up to at least 10 days with *P. praecox,* and for at least a week with *P. cathemerium* and *circumflexum.* That these were true infections was indicated by known lengths of the asexual cycle in the two former species, by the fact that occasionally reproducing forms were seen, by a slight, but demonstrable increase in numbers of parasites as seen under the microscope in one or two cases, and by length of incubation periods of subinoculated canaries.

66. The Control of Leucocytozoon anatis *Wickware.* (12 min.) EARL C. O'ROKE, University of Michigan.

During a period of three consecutive summers devoted to the study of this protozoan blood parasite which causes a fatal disease of ducks, it has been found that losses can be reduced or prevented entirely through management based upon a knowledge of the life history and method of transmission of the parasite. Such control applies only to domestic ducks or to wild ones raised under domestic or semi-domestic conditions. The following measures which have been found to be effective may be used singly or in combinations depending upon local conditions: 1. Cull out in the spring all infected ducks as determined by microscopic examination. 2. Have ducklings hatch either early or late, avoiding the midsummer period of greatest abundance of black flies. 3. Continue culling operations throughout the summer and do not introduce fresh lots of ducklings into a black fly area within ten days after infected ducks have been present. 4. Confine ducklings in cool, dark, sheds during the warm part of the day and early evening when black flies are active. 5. Protect ducklings from attacks of black flies with screening having 24 meshes to the inch or with cheesecloth of suitable quality. 6. Raise ducklings in black fly-free localities.

Attempted control through the administration of plasmoquine met with failure. Quinine seems to offer some possibilities in that it retards the development of gametocytes.

67. Control of Poultry Coccidiosis by Chemical Treatment of Litter. (15 min.) (Charts.) JUSTIN ANDREWS, Johns Hopkins University.

Four lots of 250 White Leghorn chicks two weeks old were housed and managed as nearly identically as possible except for sanitation and chemical treatment of litter. Two lots were placed on clean litter in pens which were cleaned each week. One of these pens was sprayed each week with a mixture of coal-tar acids in a light mineral oil; the other was not. Two lots of birds were placed on dirty litter in pens which were deliberately contaminated by the addition of 8.5 lbs. of oöcyst-containing (mixed species) litter to each. One pen was sprayed each week with the mixture mentioned above; the other was not. The treated pens showed significantly lower mortality rates, more weight and greater food consumption. An experiment was conducted repeating essentially the conditions in the two latter pens (poor sanitation) of the first experiment. The results confirmed the findings of the first experiment. It was further determined that in the absence of cleaning, this chemical mixture would not protect the flocks against epidemic coccidiosis for more than four weeks. A pen treated with a mixture of the same quantity of coal-tar acids emulsified in water failed to postpone the normal development of a coccidial outbreak.

68. Diurnal Periodicity in the Oocyst-production of the Sparrow Isospora. (15 min.) (Lantern.) DONALD C. BOUGHTON, Johns Hopkins University.

The time of day during which isosporan oocysts appear in the droppings of naturally infected English sparrows was established by a series of microscopic examinations of feces at hourly intervals throughout a 24-hour period. Under ordinary summer daylight conditions, heavy oocyst-production occurs from 3 P. M. to 8 P. M. Heavily infected birds very often show no oocysts during the forenoon. Reversal of the time of the appearance of oocysts to the period 3 A. M. to 8 A. M. takes place in birds after subjection 4 days to artificial conditions of light at night and darkness during the day. Starvation during the morning or afternoon hours does not change the time of oocyst-production provided the normal light and darkness periods are maintained. The periodicity here reported is considered to be determined, in part at least, by changes in the general metabolism of the host, which are, in turn, regulated by the diurnal habits set up in response to the alternation of periods of light and darkness.

69. An Analysis of the Cyst Count of Endamoeba coli *in a Measured Amount of Feces from Each of 431 Consecutive Stools.* (15 min.) (Lantern.) ROBERT M. STABLER, University of Pennsylvania.

(No abstract received.)

70. Observations on the Protozoan Infestations of American Indian Children in the United States. (By Title.) WILLIAM B. OWEN, RALPH F. HONESS and JAMES R. SIMON, University of Wyoming.

The data presented in this report are the results of a study of the intestinal parasites of 83 Indian boys of the Arapahoe tribe in Wyoming. Stool samples were shipped from the Reservation to the Zoology Laboratory, where all identifications were made. Of the 83 patients (examined on an average of 1.2 times), 78 or 93.9 per cent harbored one or more species of intestinal protozoa. These 78 positive cases had a total of 174 infections, an average of 2.2 infections per individual. The incidence of the separate species of protozoa was as follows: *Endamoeba coli* 68.6 per cent, *Endolimax nana* 55.4 per cent, *Iodamoeba williamsi* 34.9 per cent, *Endamoeba histolytica* 26.5 per cent, *Giardia lamblia* 21.6 per cent, and *Chilomastix mesnili* 2.4 per cent.

At the time the stool samples were obtained these boys were in a mission school and living under strictly modern hygienic conditions. However, they had spent the summer months with their families on the Reservation and they also made frequent visits to their homes during the school year. Observations on sanitary and hygienic practices among the Indian families on the Reservation, as compared with those prevailing in the mission school, lead to the conclusion that these positive cases became infected while at home. The high percentage of the cases infected with *Endamoeba histolytica* warrants a further study of the incidence of this parasite in the North American Indians and the rôle it plays in their health.

71. Relapse and Associated Phenomena in the Haemoproteus Infection of the Pigeon. (By Title.) G. ROBERT COATNEY, Nebraska Wesleyan University.

The number of parasites of *Haemoproteus columbae* in the blood of birds at the peak of a beginning infection and the rate of their destruction during the crisis show wide variations among individual birds. Heavy infections may be pathogenic. No periodicity of gametocyte production was discovered. Small numbers of gametocytes may persist in the blood from 17 to 68 days. The resistance mechanism operating within the body of the bird is thought to control the length of the beginning and relapsed infections. Relapses occur with extreme irregularity and are of widely varying intensity in birds kept under the same conditions of food, temperature and light. Relapse is regarded as entirely distinct from any possible periodicity of sporulation or any other cyclical phenomenon. The frequency of relapse is held to be linked up with the activity of the resistance mechanism. When this mechanism is operating at a low level, relapses may occur; at any other time they are inhibited. A quantitative study of an extended infection in two birds showed wide differences in the degree of susceptibility to Haemoproteus infection. Re-infection is possible after recovery from an initial infection. Relapse in *Haemoproteus columbae* infections can not be induced by artificial provocatives such as adrenalin, normal horse serum, ultra violet light or starvation. The infection may be transferred from one bird to another by injecting parasitized lung tissue, but was found to be impractical as a routine procedure. Mourning doves (*Zenaidura macroura carolinensis*) are not susceptible to *Haemoproteus columbae* of the pigeon.

72. The Influence of an Increased Burden of Phagocytosis upon Malarial Infections of Birds. (By Title.) WENDELL GINGRICH, University of Texas, Galveston.

In endeavoring to test the importance of phagocytosis in immunity to malarial infections of birds I injected large amounts (0.6 cc. to 1 cc.) of washed

chicken or pigeon red cells into canaries infected with *Plasmodium cathemerium*. The foreign red cells were injected intravenously for periods of 3 to 8 days during different stages of infection to ascertain what effect an increased burden of phagocytosis would have on the course of infection. Results are briefly as follows: (1) daily injections for 3 days during the acute rise of infection, and for 6 to 7 days during incubation and acute rise, (*i.e.*, before crisis) produced no effect on daily rate of increase in number of organisms (about 5) but was occasionally followed by fatal infection or prolonged period of recovery; (2) daily injections for 3 days immediately following crisis resulted in death or, exceptionally, in delayed recovery; (3) daily injections for 3 to 8 days beginning on 3rd day after crisis (when number of organisms was greatly reduced) caused severe relapses; (4) daily injections for 6 to 8 days during latent phase of infection produced relapses with organisms first appearing after 5th to 8th injection. From these results and previous work it may be concluded that phagocytosis is not a limiting factor prior to crisis, but from the time crisis occurs (when macrophages presumably act specifically) phagocytosis may be regarded as the defensive reaction responsible for rapid reduction in number of organisms and for maintaining the low parasite level of the latent infection.

73. The Cytology of Leucocytozoon anatis *Wickware. I. Gametogenesis.* (By Title.) Rex K. Martin, University of Michigan.

Cytological investigations on this haemosporidian of ducks were made during the summer seasons of 1931 and 1932 at the University of Michigan Biological Station. Observations on living material disclose the following: The attenuate form of the organism observed occasionally on the 10th day following infection and in great abundance thereafter, takes no part in gametogenesis, this phenomenon being found to occur in the rounded gametocytes present on the 9th and 10th days. Macrogametogenesis is complete 2 minutes following withdrawal of blood. Wet films placed in moist chambers, fixed at timed second intervals in Schaudinn's fluid and stained in Heidenhain's haematoxylin present a finely graded series of these phenomena. The endosome, characteristic of the female gametocyte, extrudes a minute spherule which comes to lie opposite the endosome and at one pole of the intranuclear spindle; the chromosomes formed at this time divide and the endosome is extruded. The cytoplasm during maturation becomes greatly differentiated. The microgametes formed by a regular process of nuclear division, the cytological details of which have been studied, are liberated within 15 seconds following maturation of the female gametocyte. The zygote develops into the motile ookinete precisely 4 hours after fertilization. The ookinete, an elongate organism possessing longitudinal myonemes, vacuoles and a highly specialized anterior region, is capable of both forward and lateral movement. Timed experimental observations were found to coincide with the same phenomena in the insect vector, *Simulium venustum*.

74. Post-treatment Infestation with Ascaris and Hookworm in Kentucky. (By Title.) G. F. Otto and W. W. Cort, Johns Hopkins University.

Children harboring ascaris and hookworm and living in an unsanitated area were effectively treated in July and August, 1930. Ascaris infestation returned nearly to its pre-treatment level in five months and after eight months (March and April, 1931) had surpassed its pre-treatment level as judged by the Stoll dilution egg counting method. In another group treated at the same time, the ascaris egg count after 14 months (September and October, 1931) was almost identical with the pre-treatment egg count. These two groups suggest a seasonal variation in the level of ascaris infestation with the peak during the latter part of the winter. The hookworm infestation, reduced about 75 per cent by treatment, returned to about 50 per cent of its pre-treatment level in eight months.

75. Additional Observations on the Use of Fouadin in the Treatment of Dirofilaria immitis *Infestation in the Dog.* (By Title.) Paul C. Underwood and Willard H. Wright, U. S. Bureau of Animal Industry, Washington, D. C.

Four dogs, weighing 17.3 to 23.6 kilograms, and showing preliminary counts of 4 to 66 microfilariae to 0.01 cc. of blood (ear vein), were treated with intramuscular injections of Fouadin (Sodium-antimony III bis-pyrocatechin-disulphonate of sodium) daily for six days each week, treatment being omitted every seventh day. Initial daily dose was 0.5 to 1 cc. For each succeeding six-day period, the daily dose was increased by 0.5 to 1 cc., maximum daily dose being 3 cc. Total amount of drug required to effect a disappearance of microfilariae from the peripheral circulation varied from 21 to 33 cc. Time elapsing between beginning of treatment and disappearance of the microfilariae varied from 20 to 25 days. Apparently a maximum concentration of antimony in the system is necessary to effect permanent sterilization. In general, best results were obtained when treatment was pushed to the limit of tolerance in order to attain this concentration as rapidly as possible. One dog was destroyed six days after becoming negative to microfilariae; a second died three days after becoming negative. Live Dirofilaria were recovered from the heart in both animals, although heart blood was negative for microfilariae in each case. Embryos in ova from uteri of the living female worms did not respond to heat stimuli and apparently were dead. Two remaining dogs are still negative after periods of 11 and 47 days respectively. An additional animal, not in the series above, has remained consistently negative to examinations for microfilariae in peripheral circulation for a period of 333 days.

76. Studies of Bovine Coccidiosis. (By Title.) Charles W. Rees, U. S. Bureau of Animal Industry, Jeanerette, La.

An outbreak of red bovine dysentery in South Louisiana has been studied. Six cattle, under two years of age, were affected. Two cases were fatal and for several weeks the remaining four had liquid feces containing much bloody mucus and they became greatly emaciated. Cases of mild coccidiosis occurred commonly in unthrifty cattle but these cattle were heavily parasitized with hookworm, *Bunostomum phlebotomum,* stomach worm, *Haemonchus contortus* and other nematodes. It has, therefore, been impossible to assess the damage caused by the coccidia alone.

The six cases of red dysentery were parasitized by two species of Eimeria, the oocysts of which measured $26.70 \pm 0.074\,\mu \times 18.45 \pm 0.05\,\mu$ and $17.51 \pm 0.084\,\mu \times 14.78 \pm 0.05\,\mu$ respectively. The former were somewhat eggshaped and the latter ellipsoidal. They appeared, therefore, to be *E. smithi* and *E. zurnii* respectively, but no intra-residual body was found in either species. All of the oocysts that were seen in the mild cases of coccidiosis were somewhat egg-shaped like *E. smithi* but some of them were too small to fit the published descriptions. In one of the latter infections the mean for 100 oocysts was $19.86\,\mu \times 13.20\,\mu$. It had, therefore, like *E. smithi,* a length about 1½ times its breadth. This may be a race of small *E. smithi* or a new species.

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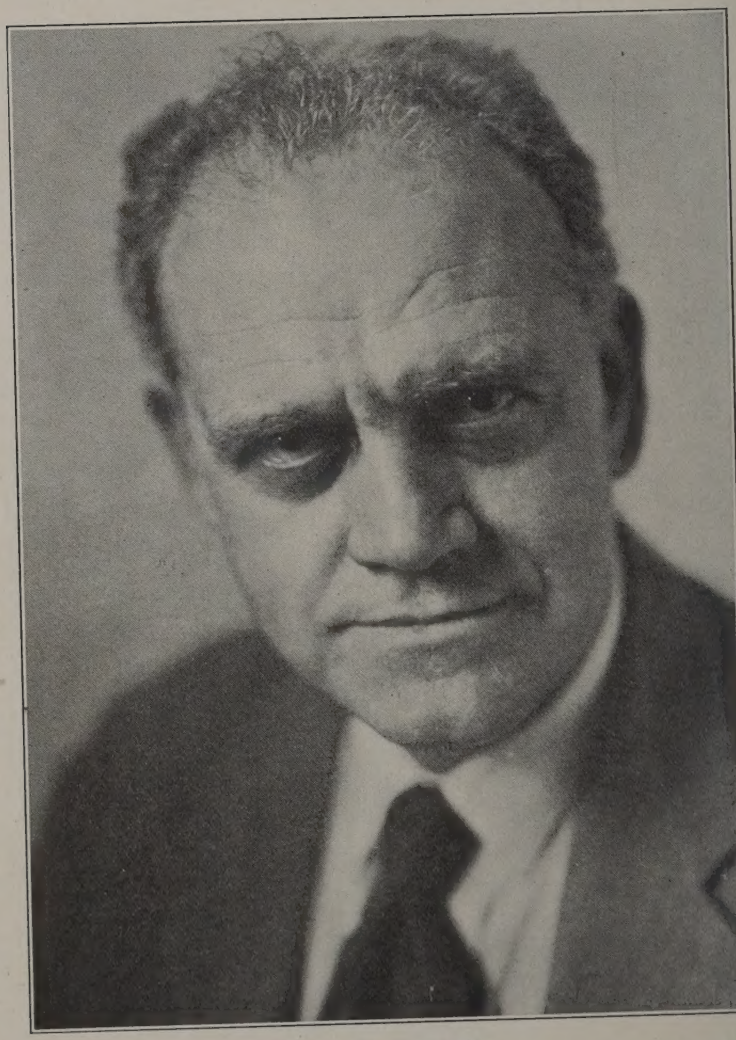

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